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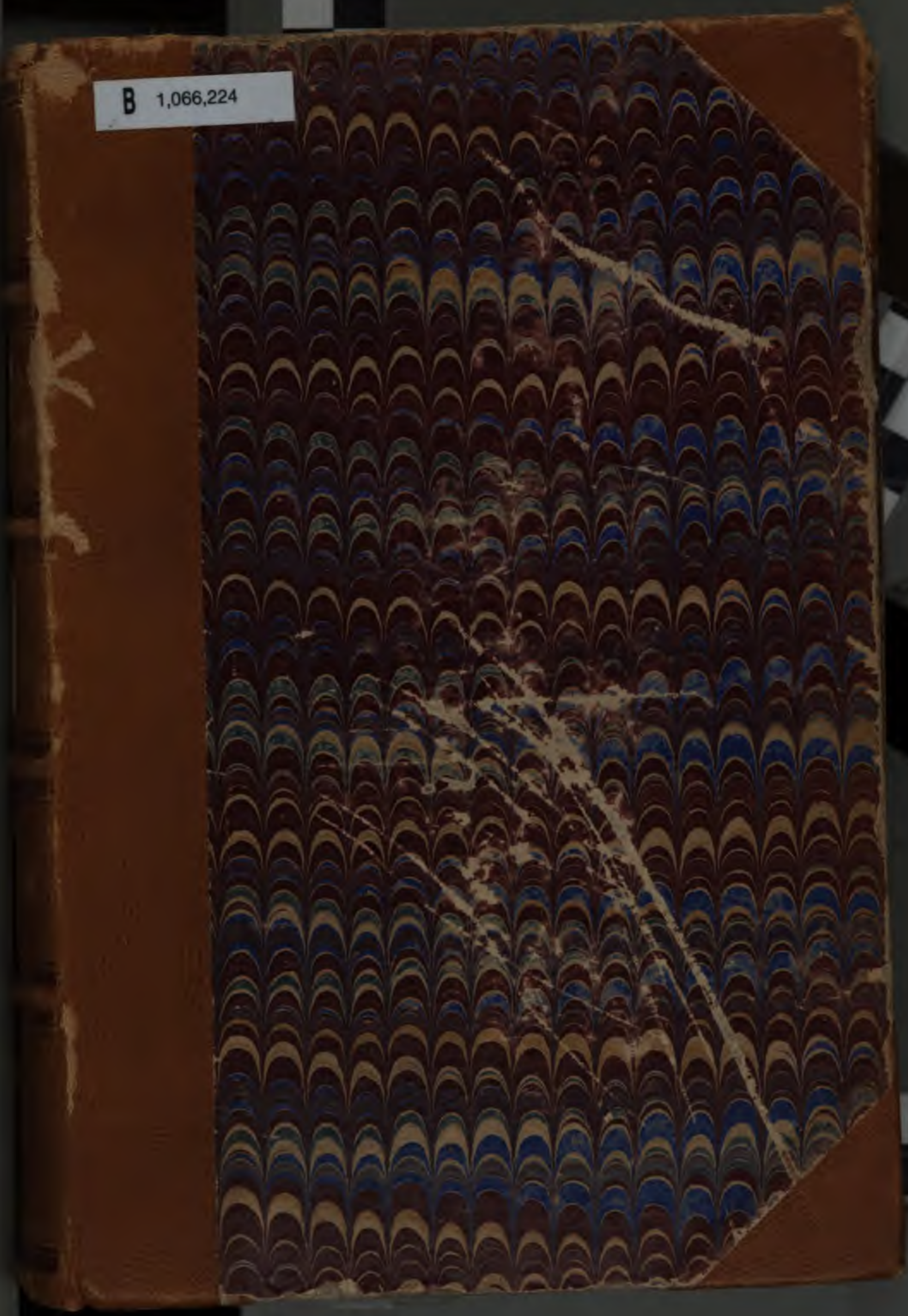

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THE

AMERICAN GEOLOGIST

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HENRY ROWE SCHOOLCRAFT.

From observations and researches by J. V. Brower, Commissioner in charge of an expeditionary examination of the Itasca Basin, on behalf of the Minnesota Historical Society, and manuscript prepared by Mrs. Jane S. Howard, only surviving member of deceased's family.*

The Peace of Utrecht, 1713, controlled the destinies of an English gentleman of education and refinement, who came to America during the reign of Queen Anne. He settled in Albany county, New York, opening an English school, and his descendants continued their residence there for a hundred years. One of the descendants of this family was Col. Lawrence Schoolcraft, a revolutionary soldier, commanding in the war of 1812 the first regiment contributed by his locality. He married Miss Barbara Rowe, of noble character and German-parentage.

Henry Rowe Schoolcraft, the subject of this brief sketch, was the seventh of a large family, the issue of this union, enjoying the advantages of an early education. He pursued an advanced course at Union college, Schenectady, and at Middle-

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*There is a biographical sketch of Mr. Schoolcraft in his *Personal Memoirs*, with a portrait, and another in the *National Magazine*, vol. VI (1865), accompanied by a portrait. There is a sketch also in the *Annals of Iowa*, July, 1865. Rev. W. T. Boutwell has also a sketch of his expedition of 1832 in the *Minn. Hist, Col.* vol. I, p. 153. The remarks of Dr. G. W. Samson, president of Columbia College, at Schoolcraft's funeral, have also been published in pamphlet form.—[ED.]

bury, Vermont. When the attention of this country was drawn to the resources of the Mississippi valley, he accepted the offer of DeWitt Clinton, at the age of twenty-four, to engage in an exploration of the country west of the "Great River," spending two years in the territory now comprising the states of Missouri and Arkansas, publishing on his return two treatises which brought his capabilities as a geologist and geographer before the public; and his services were called for as geologist and mineralogist to the expedition of Lewis Cass from Detroit, Mich., 1820, to the sources of the Mississippi.

Leaving New York city by stage March 5th, 1820, visiting Niagara from Buffalo with a horse and buggy, embarking for Detroit on the steamer Walk-in-the-Water, he arrived at his destination on May 8th. The Cass expedition, with Schoolcraft as a scientific attaché, left Detroit May 24th, 1820, and by an extraordinary canoe voyage, memorable in the history of the Northwest, proceeded through the great lakes to the west end of lake Superior, up the St. Louis river, portaging to the Mississippi, and up the great river to Cass lake, thence down the river by way of Fort Snelling, visiting Carver's cave, proceeding to Prairie du Chien, across the territory of Wisconsin, arriving at Detroit September 23rd.

During this extraordinary canoe voyage, Mr. Schoolcraft made daily observations of geologic formations and mineralogic deposits through the entire region traversed, including the copper mines of lake Superior, the lead mines at Galena and the clay deposits at Milwaukee, making a detailed report to the secretary of war, accompanied by charts of all his observations.

The Cass expedition failed to discover the great basin at the headwaters of the Mississippi. However, the peculiar capabilities of Mr. Schoolcraft, indicated by his scientific report to the authorities at Washington, placed his services in demand, and in 1830, as United States superintendent of Indian affairs for Michigan, residing at Sault De Ste. Marie, he received instructions from the Department at Washington to visit the Northwest in charge of an expedition ostensibly for conferences with the Indians, but in reality to determine the true source of the Mississippi.

Not until 1832 did the Schoolcraft expedition make its final and successful start accompanied by the Rev. W. T. Boutwell, representing the board of commissioners for foreign missions.

The Lac La Biche was known to exist, and Mr. Schoolcraft was determined to reach it, carrying out his other objects of observation while en route by canoe voyage through lake Superior. Messrs. Schoolcraft and Boutwell were personal associates, voyaging in the same canoe through lake Superior, and while conversing on their travels along the south shore of the great lake, the name "Itasca" was selected in the following manner, in advance of its discovery by Schoolcraft's party:

Mr. Schoolcraft, having uppermost in his mind the source of the river, expecting and determined to reach it, suddenly turned and asked Mr. Boutwell for the Greek and Latin definition of the headwaters or true source of a river. Mr. Boutwell, after much thought, could not rally his memory of Greek sufficiently to designate the phrase, but in Latin selected the strongest and most pointed expression— *Veritas Caput.*

This was written on a slip of paper and Schoolcraft struck out the first three and last three letters and announced to Mr. Boutwell[1] that "Itasca shall be the name." However, Mr. Schoolcraft says: "Having previously got an inkling of some of their (Indian) mythological and necromantic notions of the origin and mutations of the country, which permitted the use of a female name for it, I denominated it Itasca."

The party passed over nearly the identical route traversed by the Cass expedition, reaching Cass lake July 10th, 1832, and upon the advice, information and guidance of Ozawindib, a Chippewa chief, in birch canoes proceeded up the main tributary of Cass lake, up the smaller or Schoolcraft fork of the Mississippi, thence by portage to the east shore of the east arm of Itasca lake, and to camp on Schoolcraft island. During the day Mr. Schoolcraft traversed the entire shores of Itasca, erecting the Stars and Stripes on the island; he then returned to Cass lake, thence to Leech lake, down the Crow Wing river, and to his home and family.

For nearly fifty years Mr. Schoolcraft was in the service of the government of the United States as a geologist, mineralogist and geographer, and his reports and communications are voluminous, and, for the period of time during which his observations were made, were considered highly valuable and creditable as well to himself as to the authority he fearlessly represented.

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[1] I have a vivid description of the time, place and manner of selecting this name, from Mr. Boutwell in person.—J. V. B.

His six quarto volumes, "Archives of Aboriginal Knowledge," comprising antiquities, languages, ethnology and general history of the Indian tribes of North America, attracted much attention at the time as a valuable addition to Indian archæology and history, and Mr. Schoolcraft received numerous tokens of appreciation not only in this country, but from many scientific and historical associations in foreign lands. At the time of its publication a scholar writing to the "Philadelphia Bulletin" said: "'The ethnological researches respecting the red men of America by Henry R. Schoolcraft,' is a monument of genius, reflecting honor on the country, and placing its author among the very highest scholars of the age and of the world. In it we find accumulated with a research which defies appreciation, an industry which is incredible, and a quick piercing genius which reads the value of every fact at a glance, a mass of material which will in future ages reveal to the scholar facts which we are as yet far from being able to develop. We know that the work and the author have been praised ere now, but we have never yet heard the one or the other estimated as they deserve; for certain we are that Germany has no better reason to boast of Hammer, Purgstall, Kaiser or Grimm; France of Michelet or Lajard; or England of any of her long array of antiquarians from Leland to Palsgrave, than we have to boast of Schoolcraft, as shown in the great work in question."

In 1823, while at Sault Ste. Marie, Michigan, he became acquainted with John Johnston, Esq., and his attractive family. Mr. Johnston was an Irish gentleman—in fact, an aristocrat—of superior education and courtly manners, who claimed among his kinsmen the bishop of Dromore and Mr. Saurin, attorney general of Ireland. Mr. Johnston was attracted by the beautiful daughter of the renowned Indian chief of the Chippewa nation, Waubojeeg, and married her. Their eldest daughter Jane, was sent in her early childhood to Dublin to be educated under the supervision of Mr. Johnston's kindred there. Mr. Johnston's means enabled him to dispense a hospitality almost princely, and Mr. Schoolcraft was among those who shared in it; and when Miss Jane Johnston returned home Mr. Schoolcraft was immediately captivated, not only by her personal attractions, but by the grace and culture of a mind that added to the advantages of education and accomplishment, the beautiful refinement of a poetic nature.

After her marriage to Mr. Schoolcraft she was a true sympathizer in all his pursuits and a valuable helper. The romantic pride which she felt because of her descent on the mother's side from one of the native kings of the country, induced her to perfect herself in the Indian language and thus she became of eminent service in promoting her husband's knowledge of, and influence among, the tribes.

Mr. Schoolcraft was retained in government service at Sault Ste. Marie for some ten years, when he was assigned to the "Agency" at Mackinac, where his home was a social center, and where many travelers of distinction found a generous hospitality under his roof. About the year 1840 he returned to his native state and located in the city of New York. In 1842 he made his long desired visit to England, and while he was absent his wife died.

Of his four children who were born at Sault Ste. Marie, two died in early childhood, one son and a daughter reaching maturity. During the war between the States, the son, as a member of a volunteer company from New York, served under Gen. McClellan and was in the seven days battles around Richmond. He succumbed to the hardships of a soldier's life and died in the hospital at Elmira, N. Y., in April, 1865. His daughter married Mr. B. S. Howard of Beaufort county, South Carolina. Mr. Howard having office under the Confederate government naturally made his home at Richmond, Va., where he and his wife still reside.

About five years after the death of his wife, Mr. Schoolcraft married Miss Mary Howard, an estimable lady from South Carolina, who was in his last years (when paralysis had made it necessary that much of the labor of his pen should be done through others) his faithful amanuensis.

For many years he had been a sufferer as the result of his exposures as an explorer in the wilds of the then unknown West. He was crippled by rheumatic affections, and for several years he could only move with the help of crutches, and though not able to go out as usual, he loved to gather his friends about him. His society was much sought by those who never suspected his infirmities and pains as he sat and filled up the moments with vivacious and fascinating conversation, so completely did his spirit rise above his physical condition.

Mr. Schoolcraft was a large-hearted Christian man, a kind father and a true friend, ever ready to extend a helping hand to those who needed it. He was of a deep religious spirit and a rich Christian experience. For many years he was an elder in the Presbyterian church. At the time of his death he was a member of the "New York Avenue Church" in Washington, D. C. He believed the Bible from end to end to be the truth —"the word of God." Unlike many professional and controversional defenders of the truth, he had a profound conviction of the authenticity and inspiration of the Sacred Scriptures and spoke as one, every power of whose mind had been mastered and bowed in reverent subjection before a teacher manifestly divine.

On the Sabbath before his death, conversing with his friend Dr. Samson, of Columbia College, who had called to see him, he went over in a calm and delightful review his whole course as a christian man. When allusion was made to the services he had rendered to science by his laborious and sacrificing life, he exclaimed with earnestness, "that is nothing, *nothing* compared with my interest in Jesus Christ as my Redeemer." He died on the 10th of December, 1864. His noble mind triumphed till the end; calm, clear and thoughtful as when he sat with his pen at his literary toil, until he breathed his last.

The funeral services were conducted by Rev. Dr. Gurley of the Presbyterian church, Rev. Dr. Hall of the Episcopal and Rev. Dr. Samson, president of Columbia College; and his remains were laid in the congressional cemetery in Washington, D. C.

We must judge of Mr. Schoolcraft as of the times in which he lived—geology then being in its infancy in the western country.

As an explorer and discoverer he knew no failure, and his portly physical manhood permitted him to overcome almost insurmountable obstacles. He has been very generally accredited with the discovery of the true source of the Mississippi, although in late years, the fact that Wm. Morrison had reached the great basin in 1803 has caused some detraction from that claim.

The memory of the subject of this brief memorial will live in the history of the West until time shall turn all things to eternity.

LIST OF SCHOOLCRAFT'S PUBLICATIONS.

Scenes and adventures amid the semi-Alpine country of the Ozark mountains of Missouri and Arkansas with a view of the lead mines of Missouri, New York, 1819; Philadelphia, Lippincott, Grambo & Co. 1 vol. 8vo, pp. 256. 1853.

View of the lead mines of Missouri; including observations on Missouri and Arkansas; New York, 1819, 8vo.

Journal of a tour into the interior of Missouri and Arkansas, performed in the years 1818-19, map, London, 1821, 8vo, pp . 102. (In Phillips New voyages and Travels, vol. IV).

Narrative journal of travels from Detroit, through the great lakes to the sources of the Mississippi river in 1820; Albany, 1821. 8vo.

Remarks on the prints of human feet observed in the secondary limestone of the Mississippi valley. *Am. Jour. Sci.* vol. V, p. 223; Ibid, vol. XLV, p. 22.

Remarkable fossil tree found about 50 miles southwest of lake Michigan by his excellency Gov. Lewis Cass and Mr. Henry R. Schoolcraft in August, 1821, on the river Des Plaines in the N. E. angle of the state of Illinois—extracted from a paper presented by Mr. Schoolcraft to the American Geological Society. *Am. Jour. Sci.* vol. IV, p. 285, 1822.

Account of the native copper on the southern shore of lake Superior, with historical citations and miscellaneous remarks, in a report to the Department of War. *Am. Jour. Sci.* vol. V, (1822) p. 201.

Notice of a recently discovered copper mine on lake Superior, with several other localities of minerals. *Am. Jour. Sci.* vol. VII, (1823) p. 43.

Travels in the central portions of the Mississippi valley, (1821); New York, 1825, 8vo.

On the existence of lunar tides in the waters of the great North American lakes. (Letter to major Henry Whiting). *Am. Jour. Sci.* vol. XX, (1831) p. 213.)

Discourse delivered before the Historical Society of Michigan, Detroit. (Noticed in *Am. Jour. Sci.* vol. XX, 1831, p. 166. Another address on the condition of the North American Indians; May, 1832, is noticed in vol. XXIV, p. 190).

Narrative of an expedition through the upper Mississippi to Itasca lake, the actual source of this river, embracing an exploratory trip through the St. Croix and Burntwood (Brulé) rivers in 1832, under the direction of Henry R. Schoolcraft. Harper Brothers, New York, pp. 307, 8vo, 1833. (Besides the narrative this work embraces the following by Mr. Schoolcraft: Localities of minerals observed in 1831 and 1832 in the northwest; Indian languages, part of a course of lectures delivered before the St. Mary's committee of the Algic society).

Discourse on the origin and character of the North American Indians. *Mich. Hist. Soc.* Sketches, 1834; small, 12mo, p. 51.

Algic researches, comprising inquiries respecting the mental characteristics of the North American Indians; Harper Brothers, New York, 2 vols. 12 mo.

On the action of the North American lakes; (noticed in *Am. Jour. Sci.* vol. XXIV, 1842, p. 368

Observations respecting the Grave Creek mound in western Virginia. *Am. Eth. Soc. Trans.* vol. I, p. 367, 1845.

Oneota; characteristics of the red race of America; New York and London, 1845, 8vo.

Incentives to the study of the ancient period of American history. Address before the New York Historical Society, 17 Nov. 1846. *N. Y. Hist. Soc. Proc.* 1846.

Notes on the Iroquois, Albany, 1847, 8vo, pp. 498.

The Indian in his wigwam, Buffalo and Auburn, 1848, 8vo.

Personal memoirs of a residence of thirty years with the Indian tribes on the American frontiers, 1812-1842; Lippincott, Philadelphia, 1851. [Portrait of the author].

Summary narrative of an exploratory expedition to the sources of the Mississippi river in 1820, resumed and completed by the discovery of its origin in Itasca lake in 1832, Philadelphia, Lippincott, Grambo & Co., 1854. (Besides the narrative the following of Mr. Schoolcraft's papers are included in the appendix: Report on the copper mines of lake Superior; Observations on the mineralogy and geology of the country embracing the sources of the Mississippi river and the great lake basins; Report on the value and extent of the mineral lands of lake Superior. in reply to a resolution of the United States congress; Rapid glances at the geology of western New York beyond the Rome summit, in 1820; A memoir on the geological position of a fossil tree in the secondary rocks of Illinois, 1822; A letter embracing notices of the zoology of the northwest, addressed to Dr. Mitchell on the return of the expedition; Memoranda of climate. phenomena, and the distribution of solar heat, in 1820; Limits and range of the *Cervus sylvestris* in the northwestern parts of the United States; Remarks on the occurrence of native silver and ores of silver in the stratification of the basins of lakes Huron and Superior; A general summary of the localities of minerals observed in the northwest; Geological outlines of the valley of the Takwymenon, in the basin of lake Superior; Suggestions respecting the geological epoch of the deposit of the red sandstones of the St. Mary's falls, of Michigan).

A curt history of the United States (In the Hebraic manner). *Knickerbocker Gallery*, 1855. Has a portrait of Schoolcraft.

Archives of aboriginal knowledge; original papers laid before congress respecting the history, antiquities, language, etc., of the Indian tribes of the United States. The title of this work as published (2nd edition) by Lippincott, Grambo & Co., Philadelphia, is as follows: Information respecting the history, condition and prospects of the Indian tribes of the United States, collected and prepared under the direction of the bureau of Indian affairs, per act of Congress of March 3rd. 1847, by Henry R. Schoolcraft, LL.D. Illustrated by S. Eastman, captain U. S. army, 6 vols. 4to. 1852-1855. Volume VI has a portrait of the author as frontispiece. The second edition was much corrected and improved.

Discovery of a coal basin on the western borders of the Lake of the Woods, *Am. Jour. Sci.* (2) vol. XIX, (1855) p. 232.

Memoir on the history and physical geography of Minnesota, *Minnesota Historical Collections*, vol. I, p. 108.

Myth of Hiawatha and other oral legends mythologic and allegoric, of the North American Indians, 12mo, 1856, Philadelphia, Lippincott, (and London).

In 1844 Mr. Schoolcraft made a report to the New York Historical Society on the aboriginal names and geographical terminology of the state of New York. The next year he read a paper before the same society entitled "Historical considerations on the siege and defence of fort Stanwix in 1777." He also submitted to the Smithsonian Insti-

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tution a plan for the investigation of American ethnology, and contributed to the Danish Society of Northern Antiquaries archeological investigations on western Virginia, Ohio and Canada.

"He wrote also: The rise of the west! or a prospect of the Mississippi valley, a poem; Gehale, an Indian lament; Indian melodies; The man of bronze; Iosco, or the vale of Norma: Talladega, a tale of the Creek war; Helderbergia, an apotheosis of the anti-rent war (anonymous);" [Annals of Iowa]. An allegorical poem of his also appears in his "Journal of a tour into the Interior of Missouri and Arkansas," published in Phillips' "New voyages and travels," vol. IV, entitled "Transalleganiа, or the groans of Missouri."

CLASSIFICATION AND ORIGIN OF THE CHIEF GEOGRAPHIC FEATURES OF THE TEXAS REGION.[1]

By ROBERT T. HILL, Austin, Texas.

I.

In this paper it is proposed to give a brief classification of the topographic and geologic features of the extensive area of Texas. Evidently so brief a mention of this vast region will be neither exhaustive nor detailed; it is a preliminary statement of some of the great features which will be more accurately delineated by those who with better facilities will hereafter conduct accurate surveys of this region, which has as yet been only partially reconnoitered.[2]

The size of Texas can best be appreciated by remembering that it constitues in area one-twelfth of the Union, and possesses nearly every topographic and geologic condition found in the states south of the glacial region. It reaches one-half the distance from the waters of the Gulf of Mexico to those of the Pacific, and its longitude is proportionally great. A general idea of the diversity of its natural features can be obtained by brief comparison with the more familiar conditions of the adjacent states. The northeastern corner of the state is a continuation of the forest covered sands and clays of the low southern cotton belt with its characteristic natural and cultural aspects; the southwestern corner, west of the Pecos river is a prolongation of the Rocky mountain and basin topography, with its unique geology and is radically different from the section first mentioned; the extreme northwestern corner, or the Panhandle, is the southern end of the great plains, familiar to us in their northern extent through Colorado, Kansas and Nebraska. Between these diverse regions —the cotton belt, the Rocky mountains and the Great Plains— and entirely surrounded by them, lies the main portion of the state, exceeding all others in area, and so incomparable to any other portion of the United States that it is peculiarly worthy to be called Texan. It possesses almost as great a diversity of geologic and topographic features as all the others. To scientifically differentiate and define this Texan region and establish for it a proper appreciation in the minds of our geographers and geologists is the object of this paper.

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[1] For a statement of the previous classification of the topography of Texas, see bulletin 45, U. S. Geological Survey, entitled "The present condition of geologic knowledge of Texas," pp. 52-53.

[2] The Texas state survey, under the vigorous administration of Mr. E. T. Dumble, is now prosecuting a survey of this interesting portion of the United States, which has so long been neglected, and to which I have endeavored to attract scientific investigation. This paper is not intended to forestall any results of the survey, but to place at its disposal the matter herein contained.

Topographically the Texas region consists of a series of extensive, elongated parallel benches and plateaus, extending approximately in a north and south direction, and abruptly terminated at each end by great mountain systems extending at right angles to them—an arrangement comparable to a wide stairway, in which the plains are represented by the steps, and the mountains by the enclosing walls. This analogy can not be carried far, for great irregularities and depressions will be found in the width and tread of the steps, and the structure of the mountains, which represent the enclosing walls, is of two entirely different schools and periods of architecture. The wear and tear of time has scarred and disfigured the region, leaving footprints where the drainage or other erosion has crossed the plains and worn the mountain walls.

In this paper it is proposed to classify these features in the sequence of topographic origin, as follows: (1) Plains. (2) Valleys, or depressed areas produced by the erosion of plains. (3) Mountains, which may be considered disturbed and crumpled plains.

(1). *The Plains of Texas.*

The steps, or plains, with one exception, are treeless, and upon close examination, prove to be a series of ancient base levels, which have been elevated more or less rapidly and intermittently in post Cretaceous times. These increase gradually in altitude towards the interior, varying in hight from sea level to more than three thousand feet. Beginning at the coast these may be temporarily classified as follows: (1)

The Coast Prairie region. (2) The Sandy, Forest, or Lignitic region. (3) The Grand Prairie region. (4) The Staked Plains.

The Coast Prairies.

The coastal portion of the main land of Texas, from the Louisianian to the Mexican border, extending inland from fifty to one hundred miles, consists of a perfectly flat, usually timberless plain, elevated not over two hundred feet above the gulf at its interior margin, and dipping so imperceptibly eastward that it appears to be a landward continuation of the great submarine bench of the gulf of Mexico. From the deficient drainage and the inconspicuousness of its waterways, and its absolute uniformity of surface, it is evident that this plain is a newly developed surface feature which has not long been reclaimed from inundation—a fact which is further attested by its unconsolidated sub-structure and the occurrence among its fossil remains of the species still existing in the adjacent waters of the gulf. Although but a fraction of the total area of the state of Texas, this prairie is an extensive formation, occupying many hundred square miles. It is, perhaps, the best example of a newly born topographic plain in this country and approximates to an ideal, present base level. This feature can be studied along the lines of the Southern Pacific and Texas Central railways, between the Sabine and Hempstead, Texas. Stratigraphically, this formation has been but little studied. The absence of timber is due to poor drainage, and the salinity and compactness of the structure. Concerning its evolution and history more will be said in the conclusions of this paper. Its interior margin is rolling and its transition into the next feature is abrupt. Its structure and age have never been defined or delineated with any satisfaction, and are a fertile field for investigation.

(2). *The Sandy Lignitic, or Forest Area.*

The western, or interior border of the Coast Prairie region, becomes slightly undulating, and is immediately succeeded by a radically different topographic and geologic aspect. The altitude perceptibly increases, and a more or less continuous forest succeeds the prairies. The soil presents the red and white aspects peculiar to the sands and clays of the Tertiary and Quaternary formations of the Gulf States. This is the southwestern termination of the great Atlantic timber belt, which covers with its mantle of a continuous flora the whole of the Atlantic slope (except the Coast Prairie) and the Appalachian region. This penetrates the northeastern portion of the state and continues southward across it toward the Rio Grande, but becomes less conspicuous, and almost obsolete south of the Colorado river, where the climatic conditions are more arid. Its western border terminates abruptly, as if there were, though there is not, some great topographic barrier, as a lake or a desert. To the ordinary observer there is no reason why the forest should end so abruptly, but to the geologist it is readily explicable when he perceives the radical change in structure and composition of the underlying formations, the western border of the forest coinciding almost exactly with the western border of the previous soils of the arenaceous, non-calcareous, post-Cretaceous formations, and that of the compact, super-calcareous marls of the Cretaceous. The post-Tertiary subsidence has reduced the parting of the Upper Cretaceous and Tertiary formations to a common level. Almost concealed by this forest covered area of northeastern Texas, is a most interesting topography. In riding over it, with the view obscured by the dense timber, it at first glance appears to be a succession of rounded hills, but an occasional flat-topped divide is reached, which, upon comparison with others, proves that the whole country is the remnant of a greatly degraded but still distinguishable plain and that the inequalities are those of the drainage slopes. These drainage basins, owing to the readiness with which the unconsolidated structure yields to erosion, now occupy a far greater area than the remnants of the ancient plain in which they are carved. The present level of the rather sluggish streams is from 100 to 200 feet beneath the divides, and very little above tide water. Their flood-plains are wide and somewhat unstable. a few feet above these are the inevitable accompaniments of all the major streams of the southern planting region, known as second bottoms, often a mile or more in width, while still above and beyond these, marking the edges of the valley, may be one or more benches, which are usually inconspicuous, because of the unstable condition of the unconsolidated structure and the resemblance between the transported terrace material and that of the underlying beds. The flat-topped divides and wide valleys characterize the whole extent of the region, which is an ancient plain, whose individuality has nearly been destroyed in the process of its reduction to modern base level, and by the elevation and subsidences which it has undergone in post-Tertiary times, of which more will be said later on. Within this timbered area there is a great diversity of minor topographic and geologic features similar to those mentioned in my Arkansas report, which can not be described here. The most conspicuous of these are (1) minor prairies of late Quaternary origin, and (2) a great deposit of gravelly debris extending from Arkansas to the Rio Grande. These late Quaternary prairie formations are of two kinds of sediments and possibly of two epochs. In north Texas, as at New Boston, and in Arkansas, they are composed of sterile clay derived from the Ouachita system and are of no agricultural value. South of the Trinity, extending to the Rio Grande, they are known as "black prairies," and are often confounded with the true Black Prairie region, described later, for their structure is the debris of the chalky formations of the latter, degraded, transported and redeposited in later times—one of the numerous examples of redeposition so abundant throughout the cotton belt. These prairies are of varying extent and distribution. I tentatively consider these of later origin than the gravel. The gravel marks the line of sea level at the epoch of the deposition of the Plateau Gravel of Arkansas, which was early Quaternary, of which it is the direct southern continuation, the general trend of that formation changing after crossing the Red river, from west to west of south, and leaving the mountain system to the north. The average altitude of this great gravel deposit is from four to five hundred feet, and its width seldom exceeds fifty miles, yet it extends intermittently from the Ouachita to the Rio Grande, and doubtless it will some day be correlated with the Mississippi and Maryland deposits of a similar nature and the intimate relation of the time of its marine deposition to the entirely different, glacial phenomena of the northern states, fully deciphered. The material of this great gravel deposit varies with the character of the formation of the interior from which it was derived, and has not been transported from the north. In Arkansas it is clearly the debris of the Ouachita system against which it was deposited. In the central part of its extent in Texas it is composed of the debris of the granitic and older limestones (palæozoic) of central Texas. Southwest of the Colorado it is made up of flint, the quantity of which is so great that it exceeds the power of one's imagination. to consider the enormous amounts of chalk deposits of the Lower Cretaceous which must have been destroyed during its deposition. Another problem awaiting future solution concerning the Lignitic area is whether the ancient base level which the gravel represents did not also include the Black Prairie region next to be described. There is also some evidence that while the eastern border of it was thus included, the main portion of the black waxy area was a nearly allied, but slightly earlier epoch. The chief and prevalent structure of the Lignitic area, however, is that of alternations of unconsolidated sands and clay of a thousand or more feet of thickness of the extensive formation known as the Eo-Lignitic, or basal Tertiary. These sands contain minute black specks of glauconite or limonite, which, owing to the porosity of the formation, quickly undergo hydrous oxidation, lixiviation and segregation, giving the country its red color and causing the stratified beds of workable iron ores. Topographically and historically then it may be considered the remnant of an ancient plain which has been much degraded by atmospheric agencies and alternations of post-Tertiary subsidences and elevations.

The Black Prairie Region.

Immediately interior of the Sandy Lignitic area, radically different, lies the Black Prairie, the richest and largest continuous body of agricultural land in Texas, and hence the most important from a cultural as well as scientific aspect. It extends in an unbroken body across the state from Indian territory to Mexico. The narrowest portion of its area is about twenty miles in width west of Austin where the Colorado transects it. From that point, however, it widens in both directions until its broadest margins—over one hundred miles in width—rest upon the Red and Rio Grande respectively. The topography of the area was well defined by Dr. Ferdinand Roemer, some forty years ago, as the "Sanftwellige hügle land." or gently undulating region. When viewed from a distance it is apparently level, but upon closer inspection it is found to consist of many gentle undulations, which seem to differentiate it throughout its extent from the topography of other prairies. The soil is very black and sticky when wet and has the tenacity of wax, from which fact is derived its name. It is the residuum of the thousand feet of chalky clays (marls, in the English sense). The black color, which is superficial, is caused by the reaction between the excess of lime and the roots and debris of the surface vegetation. The average altitude of this prairie is from 500 to 800 feet throughout its extent and constitutes a uniform bench or plain sloping gently to the southeast. As above stated there is no perceptible scarp or other topographic line of demarcation between its eastern border and the timbered region, except the cessation of timber growth, but its western border is everywhere most conspicuous from strong escarpments. The nature and origin of these scarps, however, are radically different north and south of the center of the state. From the Red river to the Colorado the western border is marked by the scarp of white chalky rock (the westernmost outcrop of the Austin Dallas chalk, Niobrara) surmounting blue clay shales (Eagle Ford shales). This escarpment is continuous except where cut by rivers, from Austin to Denison, 200 miles above the depression occupied by the Cross Timbers to the west. In common with every other inequality of the earth's surface in Texas, this scarp is locally called "mountains."[1] The chalk is likewise known as "white rock," and hence I propose for it the name of the White Rock scarp. It can be distinguished even upon ordinary maps by the small fringe work of minor streams which drain its summit to the eastward, and the streams which are deflected along the strike of its base. The chalk or white rock forming the summit of this scarp is the immediate geologic antecedent of the marly clays underlying the main black waxy area, and I classify it as a subdivision of the black prairie region. It marks the western border of that region throughout its extent, but seldom has an areal outcrop of more than a mile or two. Its topography is slightly different from the main prairie, in that it is a little more undulating and usually covered with a sparse growth of handsome live oaks. In general appearance it is always contrasted with the Downs of England by those who have seen both regions. Immediately beneath the chalk there is another horizon of clays (the Eagle Ford shales) which, especially north of the Colorado, makes another black waxy strip of a few miles in width. The sixth ward of Austin is typical of this subdivision of the Black Prairie. This is especially conspicuous in Hill, Dallas and adjoining counties. It is usually flat, or possesses undulations of the diminutive character known as hog-wallows, caused by the shrinkage, cracking and erosion of the calcareous marls under the alternating conditions of extremes of moisture and drouth. For this subdivision which has not hitherto been differentiated, I propose the name of the Minor Black Waxy, or Eagle Ford prairies.

This escarpment and its accompanying valley are like those in the middle districts in Britain running from Yorkshire towards Dorsetshire, between the Chalk range of the North Downs and the parallel ridge of the Lower Greensands, and described by Phillips[3] as valleys of stratification, "which are chiefly alternations of clays and limestone resting successively upon each other and tilted up at an angle so that the several beds dip to the southeast," exactly as in the case of White Rock scarp, the Washita or Fort Worth limestone representing the harder over and underlying limestones, and the Eagle Ford clays and the Lower Cross Timber sands the softer included layers. "The clay being formed of impalpable mud, has its surface particles loosened year by year under the influence of atmospheric agencies, etc. Thus, in time, the clay becomes hollowed out into a valley more or less deep and broad, while the limestone, which is less easily broken up by the frost and has few loose particles which can be carried away by water and is only slowly dissolved by the carbonic acid, * * * * wastes less rapidly * * * * and hence stands up as a terrace margining the valley hollowed out in the clay below it." And such is the origin of the White Rock scarp and the lower Cross Timber valley. It should also be remembered that such valleys and scarps of stratification are receding in the direction of the inclination of the rock sheets, and later a question will arise, how far has the White Rock scarp in the past traveled eastward across the state of Texas? In other words, what was the former extent of the white rock? Other conspicuous scarps of stratification in Texas are those of the Staked Plains and Grand Prairie to be mentioned later.

The Balcones next to be described, upon the other hand,

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[3] Physical Geography and Palæontology, Seeley, p. ——.

are scarps of elevation and faulting produced by the pushing up or falling down of the country upon one side or the other. It should not be forgotten, however, that every scarp and valley of stratification is necessarily the consequence of the antecedent disturbance or elevation of the earth's crust which raised the accompanying strata to their present inclined position, and the line of this original disturbance is an important bearing upon the origin and evolution of the topographic features under discussion. South of the Colorado the western border of the Black Prairie is no longer a declivity, but ends against an elevation—not of its own area, but of the region against which it abuts.

The Balcones.

This scarp, although apparently a continuation of the foregoing, is not related to it by origin or by direct connection. It is an important and conspicuous topographic feature in Texas. This feature has frequently been referred to by the writer as the Austin-New Braunfels non-conformity, for it is along its line south of the Colorado, that the rocks of the lower Cretaceous series which form the highlands of the Grand Prairie, dip so unconformably between those of the Black Prairie, or upper Cretaceous region, accompanied by faulting of several hundred feet.

In traveling across the Black Prairie, the western border is terminated by what is apparently a low mountain system rising two or three hundred feet above it. Upon ascending this it is found to be surmounted by a level plateau—the scarp being the eastern face of a great monocline which marks the border of the Grand Prairie next to be described. The International railroad follows the foot of this escarpment from Austin to San Antonio, and the Southern Pacific follows it from that city westward to the Rio Grande. The topography of this feature was partially represented upon some of the earlier maps of Texas as a mountain system, especially on the geological map published by Dr. Ferd. Roemer in the year 1842. The Spanish speaking people—ever ready with an appropriate descriptive geographical name—have called this scarp west of San Antonio "El Balcones."

Why the Grand Prairie south of the Colorado should thus terminate in an eastwardly facing scarp, while the one north of that stream faces in a direction apparently opposite to it has long puzzled the writer, and only lately has the reason been discovered. The line of the Balcones is a fracture extending across Texas from Mexico to Arkansas. North of the Colorado, however, it is concealed by the overlap of the Black Prairie, beneath which it extends onward to the Ouachita mountains. South of the Colorado it elevates the eastern edge of the Grand Prairie, north of that stream it elevates the western edge of the Black Prairie.

The Grand Prairie, whose rocks before the culmination of this disturbance dipped sharply eastward, were elevated west of it to an almost horizontal position, while the southern division of the Black Prairie, at least in places, was lowered after the manner of the downthrow of a fault. This line of disturbance continues six to ten miles north of Austin, crosses into the northern division of the Black Prairie region, which it traverses in a direction a little east of north, and slightly oblique to the strike, thereby elevating its western edge.

This disturbance is marked by two conspicuous and probably associated phenomena. The first and most intimately connected of these is a line of springs which find their way to the surface through the fault and joints overhanging the line of disturbance. The most conspicuous of these are the springs of the Leona, the San Pedro springs at San Antonio, which are the immediate source of the San Antonio river; the springs at New Braunfels, and the springs of San Marcos. Near Austin, the Barton, Mormon, Sieders, and a group of magnificent unnamed spring in the bluffs of the river, immediately west of the city, mark the line. North of the Colorado the springs of Round Rock, Georgetown, Salado, and those southwest of Dallas, mark the line. All of these are great gushing streams of water bursting suddenly from the rocks, and flowing off in large streams, discharging thousands of gallons per hour. They are natural artesian wells made by rents in the rock.

It is an interesting economic fact that anywhere within a few miles of these natural wells, artificial ones can be obtained by boring, as has been done at San Antonio, Fort Worth, Austin and Waco.

The Shumard Knobs.

The second interesting phenomenon intimately connected with this disturbance is a number of laccolitic, possibly volcanic, outcrops, which extend across the state in a line almost coincident with the Balcones. These have partially been described in previous papers; the most conspicuous examples are old Fort Inge, near the present town of Uvalde, and Pilot Knob, south of Austin. The dikes reported at Rockwall, some two hundred miles north of the last mentioned locality, and the peridotite outcrops of Pike county, Arkansas, recently described by Branner, are directly in the trend of the disturbance. A more intimate connection will no doubt be shown when the intervening region is explored. For these hills I have proposed the name of Shumard Knobs, in honor of the brothers, G. G. and Dr. B. F. Shumard, the first state geologists. These knobs and their origin will be discussed later in a paper by Mr. Dumble and the writer.

The Grand Prairie.

This conspicuous plain lies immediately west of the Black Prairie region and extends across the state parallel with it. After crossing the lower Cross Timber, as the valley which accompanies the base of the White Rock scarp is termed, or ascending the scarp of the Balcones south of Austin, the extensive plateau of this region is reached. As shown on the map it extends across the geographic center of the state in irregular outline from the Ouachita mountains, north of Red river, against which it abuts, to the Trans-Pecos and Mexican mountains, which have uplifted and destroyed its southern end. Its eastern margin is regular, coinciding with the western margin of the Black Prairie just described. The western border, however, is more irregular and broken in outline. Like the Black Prairie this region is almost divided by destructive erosion of the Colorado into two conspicuous areas, north and south of that stream. The northern area is the elongated plateau lying between and elevated above the two vallays of the upper and lower Cross Timbers, as seen between Fort Worth and Weatherford, Waco and DeLeon, Gainesville and Henrietta, or along the line of any other transecting railway. The southern portion is similar in general aspects and structure, except that it is wider and deflects westward into the truly arid region. Although a very unique area in Texas, there is no local name given to this southern division, except that universal and meaningless term "the mountains," which is applied to its eastern and western margins—the Balcones and buttes respectively. Nine-tenths of the whole area, however, is a level plateau, which could be considered a mesa were it not for the continuity beneath the Staked Plains of a small portion along the drainage divide of the Colorado and Pecos. The central portion of the northern area is prolonged westward up the drainage divide of the Brazos and Colorado, for nearly two hundred miles, approximately following the 32nd parallel, in a narrow irregular strip of flat topped buttes and mesas.

The stratification of the Grand Prairie is almost horizontal, except along the southeastern border in the disturbed region of the Balcones, it approximately corresponds in inclination with the plateau. In color, composition, and scenic aspects these rocks and their stratification resemble no other region of North America, but I am informed by many reliable gentlemen of culture who have migrated into the region from western France and Switzerland that they are almost identical in aspect to the Cretaceous and Jurassic rocks of their native lands, a coincidence which is here given for what it is worth. To this structure and its method of disintegration is due the individuality of the topography of the Grand Prairie, and their extent is coincident.

The western border of the Grand Prairie is especially interesting and unique. Like that of the Black Prairie it is a scarp of stratification, but it would take the pen of a Dutton, or the brush of a Holmes to picture the superb carving and stratification of its beautiful topography. The edge of the surmounting plateau is from three to five hundred feet above its base, and everywhere overlooks the lower and different region upon which it borders. Owing to the innumerable alternations of hard and softer layers it presents a series of persistent benches and terraces of stratification which are uniform in contour and extent, and an imitation of water-made terraces.[5]

The line of this escarpment is very irregular, forming innumerable curves and points. Sometimes it follows the transecting rivers until almost the eastern margin of the region is reached, as at the valley of the Colorado near Austin. The entire length of this scarp with its principal meanderings across the state of Texas can be little less than 1,000 miles. Accompanying the scarp are innumerable circular flat-topped outliers of the main plateau which have been completely separated from it by this fantastic atmospheric erosion, and which fringe the margin throughout its extent. These are typical "buttes," the level mesas or tops of which are capped with the identical stratum and geological horizon which surmounts the main plateau of the Grand Prairie. In symmetry of proportion and horizontality of the composing strata; and in clearness of every detail of structure, there are no grander or more unique examples of atmospheric erosion in our country. Often these buttes are forty to one hundred miles from the main area of the Grand Prairie, and are invaluable landmarks in tracing the history of its degradation. In a previous paper I gave the central palæozoic area the name of the Butte or denuded region, from the distribution of these features over it. Among the most characteristic and typical of these buttes are Comanche peak, Hood county, Johnson's peak, Round mountain, Santa Anna mountain, Church mountain, Castle mountains, "Pilot Knob," Williamson county, the Two Star mountain in Hamilton and Comanche counties, Post mountain, Burnett county.[6]

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[5] This topography is fairly represented upon the topographic sheets of the U. S. Geological Survey, especially the Gatesville and Burnet sheets. The principles of its formation are described in chapter III of that admirable treatise "Les Formes du Terrain," by De la Nöe and De Margerie, while the illustration of the valley of the Bienne, in Jura, on plate VI, is a perfect picture of the feature under discussion.

The altitude of the Grand Prairie gradually increases from 1,000 feet at its eastern edge to 2,000 feet along its westermost border, where it is covered by the Staked Plains formation. There is little or no disturbance throughout its area.

The major rivers have cut deeply through the Grand Prairie and their valleys present the same atmospheric terracing of the western border.[7] In places these river valleys assume the aspect of vertical cañons, as in the Colorado, Pecos, Rio Grande and Red rivers. The depth of these valleys below the level of the plain increases southwestward from 200 to 700 feet. Another set of rivers are wearing their way by backward erosion across the Grand Prairie from its eastern edge. These have their origin in the springs on the east arising along the great fault line at the foot of the Balconades. The Nueces, the San Marcos, Guadalupe, San Gabriel and Trinity belong to this class. The last two have completed their journey across the plain and now head in the Central region.

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[6] In a previous list, by slip of pen, the writer included Packsaddle mountain, Burnett county, in this category. This is entirely a distinct type of geologic and geographic structure. See Walcott, Am. Jour. Sci., 1885.

[7] The drainage of the entire region will be discussed in the second part of this paper.

Although the Grand Prairie is deeply scored by the transecting streams, and its western border fantastically carved by atmospheric erosion, it is nevertheless a continuous and uniform level plain, and a unique geographic unit. The plateau is treeless and contains many characteristic species which justify its separation into a floral province, intermixed with species from the arid region. After each season of rainfall its ordinary hue of dry-grass brown is succeeded by varied flowers of indescribable beauty in their changing colors. The soil is usually shallow, and is the residuum of the chalky substructure, which is of varying degrees of induration. Its prevalent color is dark chocolate, which readily distinguishes it from other limestone soils in the state. Although differing in altitude, topography and structure from the Black Prairie region, this section has never been clearly differentiated. Owing to the shallowness of the soil and the different conditions of rainfall, but few small areas of the Grand Prairie are adapted to agriculture, while nearly every acre of the Black Prairie is utilized. The underlying structure of the Grand Prairie is that of the Comanche series,[7] consisting of alternations of chalky limestones and marls of varying degrees of induration and thickness. These rocks are so much harder than the upper Cretaceous sediments underlying the Black Prairie region that the region has been appropriately called the hard lime-rock region.[8] This name can not be retained, however, owing to the fact that the chalky rocks of the Grand Prairie are soft in comparison to the extensive areas of hard metamorphosed limestone in the older rock regions. The Grand Prairie, in view of these facts, may now be considered a plateau, with one exception, everywhere standing above the surrounding region. Its eastern edge suddenly bends beneath the black Prairie, while the eroded and scarped western edge is rapidly receding eastward. That it once covered continuously the next region to be described is evident, the present extent representing about one-half its former extent.

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[7] See "Topography and Geology of the Cross Timbers of Texas," Am. Journal of Science, April, 1887, Am. Naturalist, Feb. 1887, Proc. Philosophical Society of Washington, Feb. 1887.

[8] See "A Description of Future Texas," by Gov. O. M. Roberts, St. Louis, 1881.

The next and most conspicuous plain of Texas is the Staked Plains. Before it can be properly described, however, it is necessary to consider a great depressed area, which, except at its southeast corner, everywhere intervenes between it and the Grand Prairie.

The Central Denuded Region.

In a brief article published in the *American Journal of Science* for April, 1887, the writer included all the vast region of the northern half of Texas, lying between the eastwardly receding White Rock scarp and the westwardly receding scarp of the Staked Plains under the generic term of the Central Denuded or Butte region, since all the included topography (except that of the Grand Prairie, which in this paper is removed from the classification) is the result of erosion accompanying the recession of these scarps. This classification, being more structural than topographic, however, can only be used temporarily for present convenience.[*] The area embraces great diversity of geologic substructure, mostly of pre-Cretaceous age accompanied by a variety of topography, which may be provisionally divided as follows: (1) *The Old Rock regions*, embracing (a) the Palo Pinto or Coal country, and (b) the Llano, or Marble, Granite and Iron country; and (2) *The Red Beds*, including (a) the Abilene country, and (b) the Gypsum country.

Viewed from any point upon the scarps of the Grand Prairie or Staked Plains which surround it, this region is seen to occupy what is apparently a depression from 500 to 1,000 feet below them and extending from the 98th to the 101st meridians, north of the 32nd parallel, into southern Kansas.

The older rock portion occupies the eastern third of the region, while the more extensive Red beds occupy the remainder.

Older Rock Regions.

From the margin of the Grand Prairie the extent of the lower, more rugged, and timber-covered areas of the central palæozoic, or older rock regions, can be seen for many miles. These are two sub-oval areas extending north and south in the geographic center of the state from near Red river to the Colorado, between the 98th and the 99th meridians, and separated by the narrow strip of the Grand Prairie beneath which they are no doubt continuous. Lithologically this northern region is composed of the older and more consolidated sandstones, limestones and clays of the Coal Measures with the same aspect of soil and flora, much stunted by drouth, and general sterility of cultural aspects like the Coal Measures of the Appalachian and Ouachita regions. The southern area, in addition to these Carboniferous rocks, possesses still older and harder rocks, consisting of limestones, sandstones and schists of the Silurian (San Saba formation), the Potsdam (Packsaddle formation) and the Cambrian (Llano formation) respectively, accompanied by some remarkable granitic upthrusts and domes, some of which, as I have previously shown in this journal,[16] as late as post Carboniferous. For the northermost of these areas I propose the name of the Palo Pinto country or Coal Region, and for the southernmost, the Llano country, or Granite region.

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[*] This Central Denuded region is an illustration of an ancient anticlinal elevation, which has been reduced to a depression by subsequent erosion. (See Part II).

The detailed stratigraphy and structure of these important regions are unrecorded in geologic literature. But it is evident from the few cursory examinations I have been able to give it that it is what was once a region of much disturbance, but not so excessive as the folding of the Ouachitas or Appalachians. While the latter have remained above oceanic inundation since Carboniforous time, their Texas counterparts were buried probably beneath thousands of feet of sediments during the lower and upper Cretaceous subsidences. It is also quite evident that this Older Rock region was the vicinity of the continental divide which from late Cretaceous to early Quaternary time separated the waters of the Atlantic from the interior lakes. That they are at present exposed through the erosion of the thousands of feet of Cretaceous strata that once covered them is evident. Their former extent and their relationship to the Ouachita system on the one hand, and the Rocky mountains on the other, are still concealed by the overlying Cretaceous rocks.

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[16] See a portion of the geologic story of the Colorado, AMERICAN GEOLOGIST, May, 1889.

The Red Beds.

North of the Colorado region and west of the Coal region the denudation of the Cretaceous strata is more complete, and there is exposed between the 99th and 101st meridian, extending north into Kansas, a large area of country for which, from the prevalent color of its surface and its affinity to similar formations in the west, to which the name'has been given, I propose the name of the Red Beds. This region is included between the scarp of the Staked Plains upon the west, the scarp of the western prolongations of the Grand Prairie upon the south, and the Palo Pinto or Coal Measures upon the east. Topographically it consists of rolling treeless plains becoming more broken toward the Staked Plains by the valleys of the numerous arroyos and wide flood plains of the few rivers that transect it. Its flora is that of the arid region. The soil is marly and void of much humus, and usually of a vermilion color. Unprotected by turf and exposed to driving rains after long intervals of drouth, the region readily yields to disintegration and denudation, producing deeply cañoned arroyos, the depth of which increases in proportion to the proximity of the plains, forming large areas known as the "breaks of the plains," making typical exposures of bad lands, similar to those of the other portions of the arid region.

The few rivers which transect the region, as the Red, the Canadian, the Brazos and the Colorado, of the second class,[11] and the Pease and Wichita of the third, possess exceedingly wide and deep valleys, with low and inconspicuous scarps and are especially marked by very wide flood-plains, filled with quicksands and out of all proportion to the small volume of water which ordinarily fills them. Those who have seen the valleys of the Platte, the Cimmaron or the Arkansas between the same meridians will readily recognize the type of streams to which they belong.

Structurally the region is composed of almost horizontal westwardly dipping[12] strata of unconsolidated clays, loosely segregated red-brown and mottled sandstones, and massive beds of gypsum which collectively compose the as yet un-measured thousands of feet of strata of post Carboniferous and pre-Cretaceous strata which have been ascribed to the "Permian," "Triassic," "Jura Trias" and other ages, notwithstanding the fact that no stratigraphic section of the region has as yet been made. That the present plateau of the Staked Plains once extended eastward across this area, meeting and overlapping the Grand Prairie, is everywhere evident from the destructive denudation now going on, and the fact that this condition still exists in the region preserved from denudation south of the Concho.

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[11] For classification of rivers of the Texas region, see vol. II, Annual Report of the state geologist of Arkansas, 1888.

[12] The Red Beds represent the western inclination of the anticline of the Central Denuded region.

This region is divisible longitudinally into two distinct subareas, the easternmost of which has the local name of the Abilene country, after the name of its principal city, and the westernmost, the name of the Gypsum country, owing to the preponderance of that mineral in its strata.

The Albilene Country.

The eastern half of the Red Beds extending along the western Red Beds border of the Palo Pinto or Coal Measure country is comparatively more level than the western half or Gypsum country. Its waters and soils are less impregnated with gypsum, and the latter are susceptible of a more profitable agriculture. In fact much of the region consists of beautiful level plains distinguishable from other prairie regions of the state by its vermilion colored soil. The lands around the towns of Abilene and Wichita Falls, and some of the so-called Concho country are characteristic of this division. Its substructure is different from that of the Gypsum country, in that it embraces the lower or "Permian" portion of the Red Bed section which is composed of rocks of a darker brown or mottled greenish color with very little gypsum. Within the past few years this region of Texas has become well settled by immigration and is now one of the thrifty portions of the state. Conspicuous features of this country are the numerous minor scarps striking north and south giving the country a terraced appearance.

The Gypsum Country.[13]

This is the western half of the Red Bed region. It is more broken than the Abilene country and accompanied by many buttes and cañons. Owing to the stratified beds of massive gypsum everywhere predominant that mineral gives the country its chief characteristic, producing variety in color of landscape, and impregnating its soil and waters with excessive proportions. It increases in ruggedness as the foot of the Plains is approached, forming in places the bad lands above mentioned.

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[13] Good views of typical Gypsum country topograpy are given in Marcy's Exploration of the Red river.

The Red Beds underlie the Plains, although they are not their surface formation, and are often cut down to by the valleys of the rivers which indent or cross them, as the Pecos and the Canadian.

It is probable that the Red Beds never extended across the central palæozoic area, and that they were laid down in an interior sea whose eastern shore was limited by that feature. More investigation is needed upon this subject and the statement is only tentative.

The Llano Estacado or Staked Plains.[14]

Within the past few years the newly constructed railways of Texas and New Mexico have placed within easy reach of the geologist this the greatest of all Texas plains, which formerly was almost unapproachable from lack of facilities for transportation. By their aid it was possible to make a preliminary reconnoissance of what is, perhaps, areally the greatest continuous and least denuded plateau of our country. Geographically the Staked Plains of Texas and New Mexico include the quadrangular region south of the Canadian, east of the Pecos and west of the 101st meridian. Topographically this region is a single plain, or mesa, terminated except at its extreme northwest and southeast corners by vertical precipices everywhere standing in grand contrast above the surrounding and lower region. The surface of this plain is smooth and unbroken, except at its edges. Its surface, as a whole, slopes to the eastward, its greatest elevation is at the northwest corner. Hydrographically the whole surface is void of running streams, and could be classified after G. DeLa Nöe as "Regions sans ecoulement," i. e., in which there are no streams, and the small amount of surface water which is not imbibed by the soil, is found in a few and widely distributed ponds. Its eastern and northern edges are incised by deep and vertical cañons of streams which are cutting by backward or head-water erosion. Two streams flow across or around the plains, but in origin they are probably antecedent thereto, as will be shown later. These are the Canadian and the Pecos. Neither of them receives any of the surface drainage of the plain. The rainfall, principally from June to September, is from 20 to 25 inches (estimated).

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[14] The name of these plains has been attributed by those of an imaginative turn of mind to a supposed row of stakes, alleged to have been set up by ancient Mexican travelers for the purpose of guide posts. It is well known however that Indian trails have existed across the Plains since they were first known, and besides the frontiersmen would not resort to such devices even if they possessed the timber for the purpose, which in the present instance it would have been impossible to secure. The term Llano estacado alludes to the great scarp or step of its borders.

The surface of the plain is everywhere composed of the rich transported sedimentary soil which I have recently described as the Staked Plains formation,[15] and which is from 100 to 300 feet deep. From its structure and composition it is evident that it is either a lacustral or alluvial deposit, laid down in late Tertiary or early Quaternary times. The formation and its resultant soil differs from all others in Texas, and notwithstanding the deficient rainfall, the plains are rapidly being settled by an industrious population.

Upon every side, with the slight exceptions above mentioned, the plain is surrounded by majestic scarps, which afford splendid vertical sections of the structure and the stratigraphy. These scarps are very irregular upon the eastern edge, and are marked by many deep, almost vertical cañons,[16] such as Cañon Blanco, which is about nine hundred feet in depth. Eastward prolongations of these plains extend down the principal drainage divides, and probably were once continuous across the present denuded region to the Grand Prairie, as is still the case with the divide of the Pecos and the Colorado. The northern and western scarps—those of the Canadian and the Pecos respectively—are more regular and less jagged. It is not appropriate at the present time to enter into a discussion of the age or detail of this structure, but it is sufficient to say that in these scarps at various places can be seen a grand sequence or strata, from the palæozoic rocks at the base of its southwestern corner, the Red Beds formations above them, the Grand Prairie formations above these, and surmounting the whole, the peculiar formation of transported loam, gravel and other soil which constitutes everywhere the summit of the plain, and for which I propose the name of the Staked Plains formation. In addition to these are several horizons at the northwestern (and perhaps along the western) border which I have not studied, one of which is the long-disputed Jurassic horizon of Marcou, for which I here propose the name of the Tucumcari formation, for convenience of reference.

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[15] American Ass. Adv. of Science, Toronto meeting, 1889.

The extreme precipitousness of the scarps, and cañons[16], the poorly developed surface drainage, all indicate that these plains are a new topographic feature, but that several important events have taken place since its reclamation, as will be shown later. There is also little doubt that the plain once extended eastward across the Gypsum and Abilene regions, as is shown by the remnants still preserved in places. It is likewise evident that this plain has been elevated at its northwest corner, and its surface tilted to the southeast.

[TO BE CONTINUED.]

ON LAURENTIAN AS APPLIED TO A QUATERNARY TERRANE.

By JOSEPH F. JAMES, M. Sc., *Washington*.
U. S. Geological Survey.

The difficulty of eradicating error when it has once crept into literature is the same as truth overtaking a lie, which will, as the old adage tells us, "travel around the world while truth is putting on its boots." This same kind of difficulty is exemplified every day in work of all sorts, and it behooves every one who notes an error to try to correct it. I have noted one of these errors which has been most persistently repeated, and its recurrence in an important and recent geological paper[1] has induced me to send the following note in the hope that the error may finally be eliminated. Reference here is made to the statement in the above paper that E. Desor had applied the term "Lawrencian" to certain drift deposits of the St. Lawrence valley, and to which same deposits Prof. Hitchcock in 1861 gave the name of Champlain. A history of Desor's use of the term *Laurentian* and its later application by Logan, as well as the erroneous references which have been made to it, are herewith given.

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[16] Some fine illustrations of these incised canons are given in "Marcy's exploration of Red river."

[1] Report of the (American) Sub-Committee on the Quaternary and Recent, by C. H. Hitchcock, Reporter. AM. GEOL. vol. II, p. 303.

oints in the St. Lawrence valley. **We find th**
meeting of the Boston Society of Natural History on F
19. 1851, and again on March 5, 1851, Desor spok
Laurentian and applied this term to drift of marin
about Montreal.[2]

Later in the year, September 28, 1851, he addressed
to a friend, Monsieur E. Collomb in which he again
the term in the same sense. This letter was printe
Bulletin of the Geological Society of France,[3] and th
tial parts, or those referring to this term, are as follow

After mentioning the action of glaciers in tran
erratic blocks, he says: "Here a new phase opens
history of the quaternary deposits; I mean the di
between the *marine* drift and the fresh water drift.
point that I have mentioned in one of my last lette
friend Martins, and who has since confirmed it. I
posed to designate the marine drift under the name
rentian, a name which is adopted by the greater part
ican geologists, and which you will find among the g
divisions used by schools.

This terrane extends all along the St. Lawrenc
tributaries as far as the foot of lake Ontario; but
appear that no part has a greater elevation than five
feet. Beyond, along the shores of lakes Erie, H
Superior extends a vast deposit in which no one a
discovered any fossils whatever, and which I hav
reason, described (on lake Superior) under the nam
simply.

"During the preparation of my report, fossils were
various points along lake Erie, on the borders of

shores of these same lakes in our own day. M. Lesquereux has recognized a quantity of leaves of pines, and many marsh plants. Imagine then a fresh-water deposit, extending from the sources of the Mississippi as far as the mouth of the Ohio, and from lake Superior to the falls of Niagara. Certainly we have nothing resembling this in the old continent, unless it be in some corner of Scotland where we are assured that certain deposits of lower *till* with the marine *till* are of lacustrine origin. The immense extent of this fresh water basin has not a parallel in geological history, not even in that of coal, especially when I consider that these same deposits extend without interruption to a level of 1200 and 1500 feet between lake Superior and lake Michigan; a thing that proves absolutely that at the epoch of their deposition the relative levels of the continent must have been different from those of our own day. I have proposed to designate this vast deposit under the name of *Algonquin terrane*, after the name of a tribe of Indians who were formerly spread over the greater part of this territory. To see this deposit in certain localities as on the southern shore of lake Erie, one would say that it is identical with your *loess* of the Rhine; but when we follow it over thousands of square miles, one soon abandons all idea of an identity of origin. I have been and I am yet uncertain as to the age of this Algonquin terrane. Before knowing its vast dimensions I was inclined to view it as contemporary with the *Laurentian*; but I have lately given up this idea, and I am tempted to consider it as anterior. I should be much obliged if you will give me your opinion on this subject."

In a second communication presented on April 5th, 1852,[4] M. Desor refers again to the Laurentian, applying the term in the same way as the "Marine drift or terrane Laurentian." The marine drift, formerly described under the name of Tertiary terrane by American geologists includes the stratified deposits of clay, of sand and of gravel with marine shells. As the deposits of this kind are most developed in the valleys of the littoral Atlantic, and particularly in the valley of the St. Lawrence and of its affluents, I have proposed to designate it under the name of *Laurentian terrane* to distinguish it from deposits containing fresh water fossils." He then proceeds to describe the fresh water deposits in detail, and this other

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[4] Soc. Geol. de France Bull. 2nd ser., vol. 19, pp. 281-285.

In the "Neues Jahrbuch" for 1853, pp. [illegible],
f a paper by Desor upon Drift phenomena in th
urope and America (published in Bull. Univ. 1
'hys. CXXI, pp. 180-184). In this reference is agai
he term Laurentian as having been applied by Des
eposits on the St. Lawrence and other places.

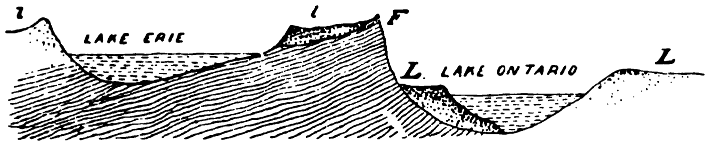
The next reference we find to the use of this ter
rift is in the appendix to Zadock Thompson's Na
ory of Vermont, published in 1853, p. 54. (Here
he term is spelled "Lawrencian"). From this t
882, the term seems to have lost its original signifi
his year Prof. J. P. Lesley in an obituary notic
ays (in a foot note[5]): "His term Laurentian for
eposits along the St. Lawrence and the lakes has
ccepted by geologists because of its subsequent
o the fundamental gneiss of the mountains
a." In the next year, 1883, Mr. M. E. Wadsworth
ntitled "The appropriation of the name Lauren
anadian geologists," published in the proceedi
oston Society of Nat. Hist.. vol. 21, pp. 121, 12
erm as originally applied by Desor, and calls atte
se by Logan and the Canadian survey for a se
ossiliferous rocks exposed very extensively in Can
he matter was dropped until in 1887 Sir J. W. D
rticle upon "Some points in which American
cience is indebted to Canada," published in the
'roc. of the Royal Soc. of Canada vol. 4, sec. 4,
résumé of the work of Logan in Canada, takes u
fter referring to Logan's work on Laurentian r
ng: "Before leaving this subject, I may menti
Sir Wm. Logan by a

and Logan's use of the term "Laurentian" for the old crystalline series was only a little later, Logan having applied the name in 1854, while Desor's use of the similar name "Lawrentian" had occurred in 1851. Logan and Hunt, who coöperated in the matter, based the name not on St. Lawrence river, but on the old name "Laurentides" applied by Garneau to the mountain range composed of these rocks. In point of fact the name "Laurentian" was based on the mountains composed of these rocks and the name "Lawrencian" on the river itself, and the latter fell to the ground as useless and inappropriate."

It is obvious that Dr. Dawson is incorrect in the statement as to the spelling of Laurentian by Desor. But it is not the purpose to discuss now the reasons given for the abandonment of the term. It is sufficient to say that if "priority of definition" and "accuracy of the original observations"[6] is to be a cardinal principle of geologic nomenclature, then justice demands the use of Desor's term Laurentian for a quaternary terrane and the substitution of some other term for the Laurentian rocks of Logan.

Since writing the foregoing I have found another article by Desor upon the same subject. It is a letter dated Feb. 12, 1851, from Boston and addressed to M. Ch. Martins, published in the Bulletin of the Geological Society of France, 2nd series, vol. 8, pp. 420-423. The substance of this letter as far as it relates to the Laurentian, together with a copy of the figure given by Desor, is presented here.

The title of the letter is "Note on the existence of marine shells of the present time in the basin of lake Ontario (Canada) at an altitude of 310 feet." After referring to the occurrence of *Tellina grœnlandica* in a stratum above lake Champlain and to the difference between the drift of the Erie and of the St. Lawrence basins he proceeds. "The cut given below



ll. LOESS. L.L. LAURENTIAN. F. FALLS OF NIAGARA.

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[6] The Taconic Sys. of Emmons, &c. Am. Jour. of Science, 3rd ser., vol. 35, p. 239, March, 1888.

represents approximately the position of the two terranes, and consequently the relative levels of the fresh and of the salt water. For a long time American geologists recognized that the deposits of marine shells are more recent than the drift of the upper lakes, and many of them for this reason have designated them under the name of the second drift. On the other hand it is evident that these deposits differ in many respects from the modern alluvium; and as they belong to a period when the distribution of land and water was very different from that in our time, I propose to designate them in the future under a particular name; and considering that they are especially developed in the basin of the St. Lawrence, we have adopted the name of *Laurentian* or *Laurentian terrane*. I shall consider myself fortunate if this name, which has been approved by the greater number of geologists of this country, obtains the sanction of the Geological Society of France. In one of my preceding communications I added some remarks upon the parallelism of this terrane with the Quaternary deposits of Europe.

"Since then I am advised that the deposits of Norway, in which one finds these shells are as much as 1,000 feet high, according to Keilhau: also that those of Sweden, with their Azar, are the analogues of our American Laurentian. There remain doubts to my mind with regard to the till of Scotland, because of its unstratified structure, and because no one has described any fossils from this epoch. But having learned from the papers of Mr. Smith of Jordan Hill, that it contains shells of recent species,[1] and that the same species are found in the deposits of clay under the till, I no longer doubt that this is the same horizon, the coarse till with its flints and striated pebbles embedded in the mud being according to all appearance the same deposits as those near Brooklyn near New York, that of a local form of the Laurentian. The deposits of the north of Germany that are distinctly stratified and contain the shells, must for a very strong reason be entered in the category of the Laurentian deposits. It remains now to be settled if there existed in some part of Europe an analogous deposit to our drift properly so called, or ancient drift, such as is found on the shores of lake Superior and in the plains of the West, and in which no one has as yet found any trace of fossils."

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[1] "The shells of the till or Boulder clay are arctic species which for the most part are not living at present in the seas of Scotland; they are in general placed above the boulder clay in the beds of laminated clay The modern shells actually living in the neighboring seas one finds upon the terraces and in the banks of sand above the clay that contains the arctic species."

I likewise find that professor J. D. Whitney in 1857[8] referred to the use of Laurentian by Logan and stated that this term had been adopted by "Mr. Desor and the geologists of the lake Superior survey for the post-tertiary deposits, containing marine fossils, which are found in the valley of the St. Lawrence and elsewhere, and which has been called "Second drift" by some geologists. The use of the same term to designate a group or system at the other extremity of the geological scale seems likely to lead to confusion, and we hope that it will be dropped for the lower system, and retained for the deposits to which it was at first applied."

It appears that Whitney and Wadsworth[9] regarded the Laurentian of Logan as a synonym for the Azoic of Foster and Whitney proposed in 1850, or four years previous to the publication of Logan's name.

The paper of professor Whitney above alluded to was noticed by E. J. Chapman, the editor of the Canadian Journal,[10] in the following words: "With regard to the term Laurentian as applied to some of these Canadian rocks, we would observe, that even if the term were previously applied to patches of post-Tertiary strata alluded to above, its peculiar fitness for the gneissoid rocks of the Laurentian range and connected country would fully warrant its retention."

Washington, D. C., Dec. 6, 1889.

CASTS OF SCOLITHUS FLATTENED BY PRESSURE.

By ATREUS WANNER, York, Penn.

[Read at the Toronto meeting A.A.A.S. 1889.]

The Hellam Quartzite, in York county, Pa., is filled with Scolithus linearis. Chickis rock, of Lancaster county, Pa., in which Prof. Haldeman first found the fossil, is an extension of the same formation. In different places good exposures of the quartzite, in situ, afford excellent opportunities for the study of the included Scolithus.

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[8] Am. Jour. Sci., 2nd ser. vol. 23, p. 314; "Remarks on the Huronian and Laurentian systems of the Canada Geological Survey."

[9] "The Azoic system and its proposed subdivisions;" Mus. Comp. Zoology of Cambridge, Bull., vol. 7, p. 340, 1884.

[10] 2nd series, vol. 2, p. 302, 1857.

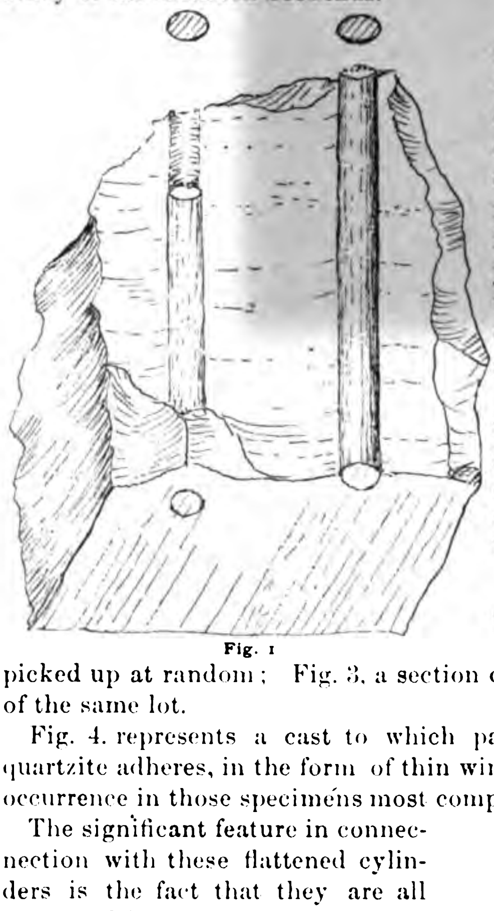


Fig. 1

The writer has been for several years carefully examining such exposures in the hope of discovering the exact nature of the fossil. Though failing in the main object, he has noticed that all casts, in every exposure thus far examined, are flattened.

Fig. 1 represents two average specimens, with sections of the same showing the extent to which both are compressed.

Fig. 2 is a section of the most circular of a hundred casts picked up at random; Fig. 3, a section of the most flattened of the same lot.

Fig. 4. represents a cast to which part of the enclosing quartzite adheres, in the form of thin wings—a very common occurrence in those specimens most compressed.

The significant feature in connection with these flattened cylinders is the fact that they are all elongated, in situ, in the same direction; and further, that the longer axes of their sections are parallel to each other and parallel to the direction of the strike of the quartzite.

In Fig. 5 we have represented a typical exposure of the quartzite. The dip of the strata is S. 30°, E. 35°.

Fig. 2.

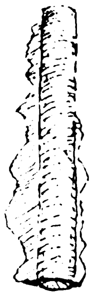


Fig. 4.

Fig. 3.

The area represented is a very conchoidal and irregular surface of fracture, at right angles to the plane of bedding, that being the direction in which the rock easiest breaks.

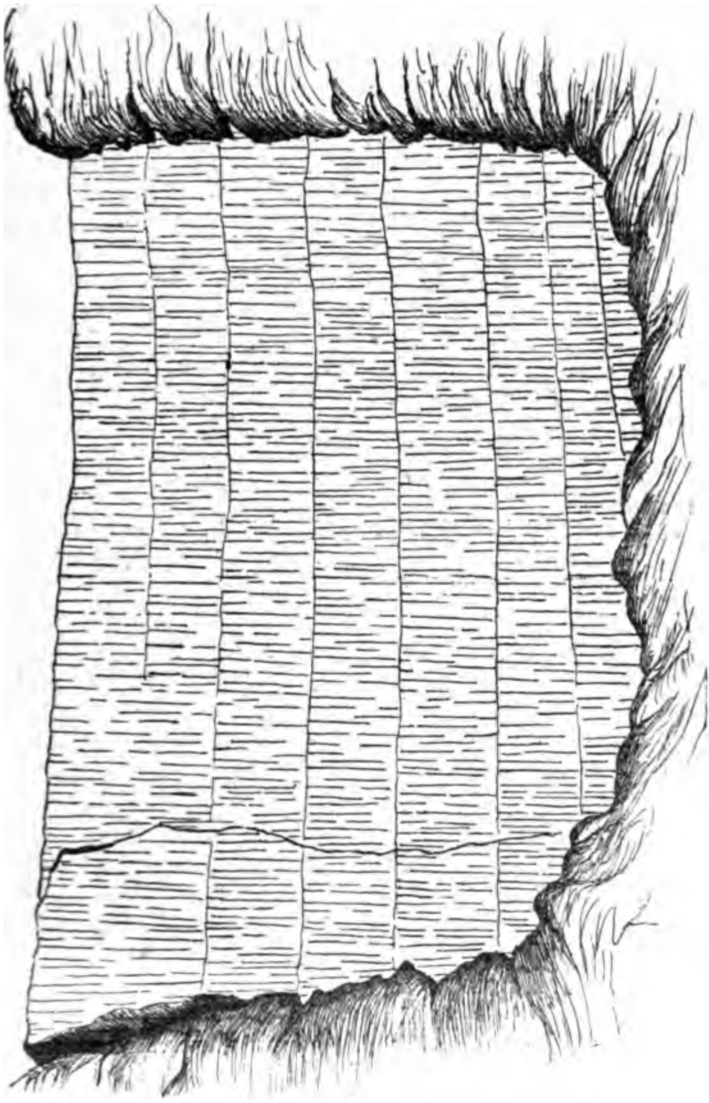


Fig. 5.

This whole surface is lined with Scolithus, extending at right angles to the plane of bedding, and displaying the invariable parallelism of the casts. In this exposure the average distance apart of the fossils is only three-fourths of an inch. All of the cylindrical casts in this exposure are flattened as stated; nor have I found in the thousands of fossils examined in the matrix, in different exposures, a single exception.

From these facts we must conclude that the cylindrical casts of Scolithus, in the original horizontal sand beds, were flattened by enormous pressure, exerted in a direction at right angles to the trend of the strata, prior to the uplifting of the formation. No other supposition is tenable, no matter what we infer the original shape of Scolithus cavities and casts to have been, whilst this partially explains the present density of the quartzite and at the same time fully accounts for the observed fact that the elongation is uniformly in the direction of the strike of the upturned strata.

Of course other conclusive proof of the direction and extent of such pressure has long been given, but I do not think that any one, prior to this, has called attention to the striking testimony of Scolithus. At any rate, if any one else observed it, I have failed to find any account of such discovery.

It may be well to state, in conclusion, that the writer's observations have not extended any further than to the quartzite of York county, Pa.

EXTINCT VOLCANOES IN COLORADO.

By Arthur Lakes, Golden, Col.

Although we have abundant signs of volcanic activity in past ages in Colorado on a grand scale, the general absence of true volcanic craters has been frequently noticed by those familiar with the geology of the state. Most of our igneous rocks belong to the class that have been erupted through fissures, from which in some cases lava has poured over the surface, the vents being filled by dykes. If craters ever existed on the surface line of these fissures, all traces of them have for the most part long ago been removed by erosion. The dyke at Valmont and the basaltic cap of the Table mountains at Golden and of the Raton mesas at Trinidad are examples. These surface eruptions are mostly confined to the more recent forms of lava, such as basalt and dolerite. Another and larger class embracing the older eruptions of porphyry and diorite, appear to have come up through fissures, but never to have reached the surface. These have sent off from the main dykes, intrusive sheets between lines of weakness in the stratification. Of this type are the pophyries of the Leadville and South Park region. A third class closely related to the last, have not only sent out intrusive sheets, but have arched up the overlying strata into oven-shaped cavities, which they have filled with massive lava, forming "laccolites" sometimes several thousand feet in thickness. When afterwards the arched strata overlying these laccolites have been removed by erosion, these great lava reservoirs have been exposed, and now form noted mountain peaks such as the Spanish Peaks near Trinidad and Sopris, Gothic and Crested Butte mountains of the Elk range. In all these cases no evidence remains of the former existence of true volcanic craters.

Amongst the summits of our mountains, we often notice deep punch-bowls or "cirques" simulating the form of volcanic craters. These are the work of erosion by water or glaciers, and are not of igneous origin.

In New Mexico, amongst the basaltic table-lands, some true volcanic craters occur.

Near Albuquerque in New Mexico and along the line of the Santa Fe railroad in Arizona, the traveler may observe flows of black, slaggy lava, in ropy coils, of exceedingly recent appearance, with little or no vegetation growing over them. These flows occupy the modern valleys and dry river courses. They are evidently of comparatively recent origin, and might possibly be traced to extinct craters further back in the mountains. In the Costilla range on San Luis park some small craters are said to exist. About four miles to the west of the little town of Antonito, on the line of the Rio Grande railway in San Luis park, just on the edge of the Conejos mountains (a range composed of enormous masses of volcanic breccia and lava flows resting upon granite) a small conical shaped mountain may be seen resting on a plateau. The Conejos river cuts through this plateau, and shows its structure to consist of successive flows of black, basaltic lava. The peculiar shape of the mountain, a low cone, with a very broad base (the angle of convergence towards the cone being about five or more degrees) suggests a central vent, from which lava flows have poured down for some miles over the surrounding flat country. The banks of the railway track are covered with large boulders, of a black vesicular basalt or scoria. The cavities or vesicles in this scoria, are sometimes several inches in diameter, and are frequently lined with white zeolitic crystals. The railway depot at Antonito is built of this black scoria. The ranchmen of the park told me there was a crater-like depression in the mountain. The cone is in full view from the railroad station at Antonito.

The Dotsero Volcano.

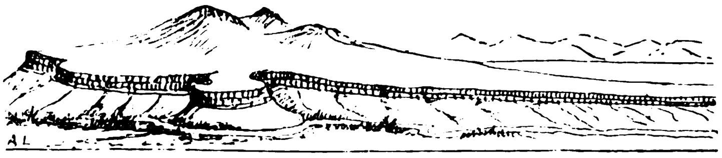
Whilst spending a few days at Glenwood Springs, Garfield county, I heard accounts of a crater and very recent-looking flow of lava being near Dotsero station, not far from the junction of the Grand and Eagle rivers, about sixteen miles east of Glenwood on the Denver and Rio Grande railroad.

I started by a freight train for the locality. Our course for some twelve or fourteen miles lay through a cañon in the Cotton-wood range. This range is formed of Cambrian, Silurian and Carboniferous strata, folded up in a faulted arch over a granite axis.

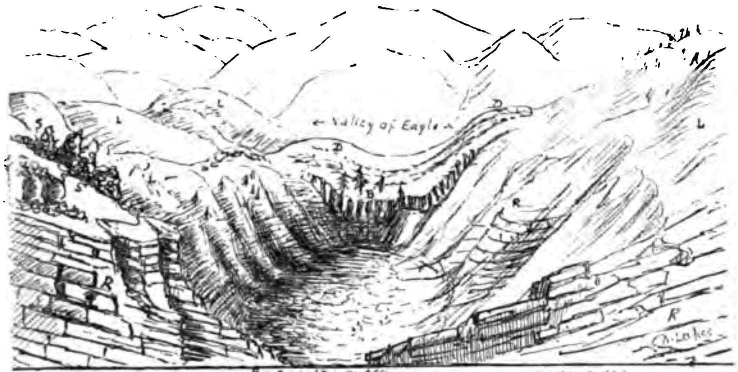
At Glenwood are the noted Hot Springs, which issue probably from deep-seated fissures, formed at a point near the commencement of the range and the entrance of the cañon, where the Triassic and upper Carboniferous strata are bent into a sharp synclinal fold. At this point of extreme compression, fissures were probably formed, which descended to sufficient depths to give rise to the heated and chemical waters of these wonderful springs. Hot springs also occur in much the same relation on the opposite side of the range.

As we emerge from the Cotton-wood cañon to the east, the country becomes more open. Upon the Paleozoic rocks, rests the Mesozoic series. The hills on either side of the Eagle, consist of the soft gypsiferous beds of the upper Carboniferous and above them in due order the red and variegated strata of the Triassic and Jurassic series.

The valley of the Eagle between the hills is from one to two miles in width. About a mile from Dotsero station the river hugs the south edge of the steep face of the hills. Just at this point a very black looking rock covers the meadow of the valley, spreading out like a large pancake, over an area of about a square mile. The edge of the cake ends abrubtly at the river side near the base of the cliff forming the south bank of the stream, the river separating it from the cliff beyond. As

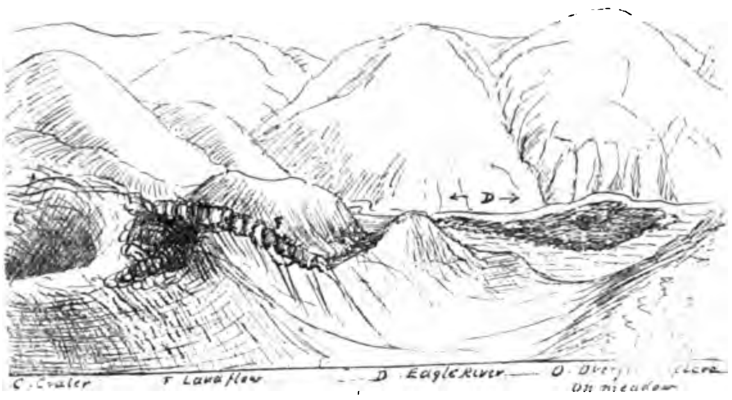


VOLCANIC Mt NEAR ANTONITO COLORADO

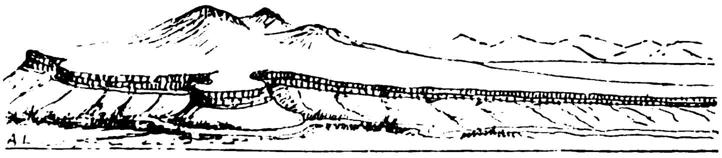


R Red Sandstone
S Scoria
B Basaltic Outflow
L. Lapilli
D Breccia Sediment

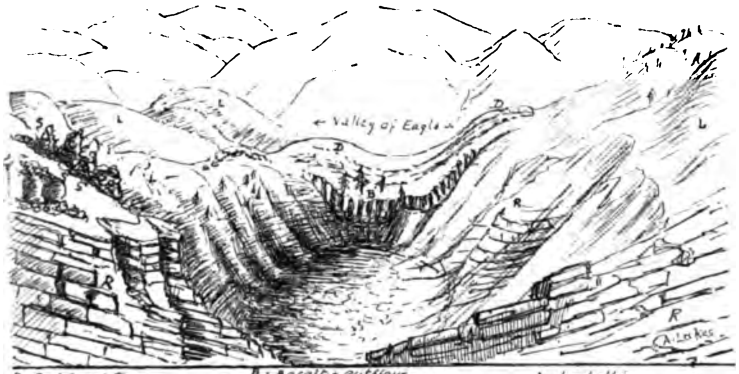
DOTSERO CRATER
COLORADO



C. Crater
F Lava flow
D Eagle River
O. Over[illegible] on meadow

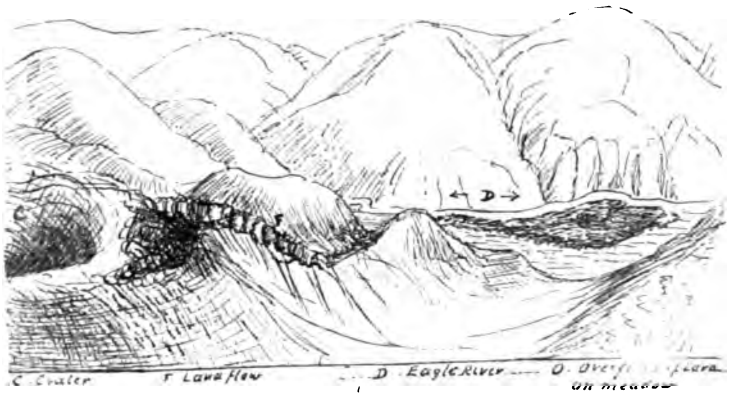


VOLCANIC Mt NEAR ANTONITO COLORADO



R Red Sandstone
S Scoria
B - Basaltic outflow
L. Lapilli
D Breccia S[illegible]

DOTSERO CRATER
COLORADO



C. Crater
F Lava flow
D. Eagle River
O. Overflow of lava on meadow

there was no bridge, I waded the stream and ascended the opposite bank. The bank proved to be a rugged cake of lava from fifty to one hundred feet thick. The central portion was of hard, massive, dark grey basalt showing a fluidal structure and a few small steam holes. Above this were masses of scoria piled up or tumbled along in chaotic confusion like the clinkers of a slag furnace. Underneath also, the lava was scoriaceous. It resembled pictures of the recent lava fields of Mauna Loa, or Vesuvius. The blocks of scoria were highly vesicular like honey-combs. The edges of the little circular steam holes were as fresh and sharp as if the flow had occurred but a week ago, and were not filled by zeolites and amygdaloids as is the case generally we believe with basaltic flows of an older date. The surface of a greater part of the flow is destitute of vegetation, a black rugged mass of slag and clinkers. Towards the opposite side of the valley, decomposition of the lava allowed a sparse covering of grass and sage-brush.

I had no difficulty in tracing the flow across the valley to the entrance of a narrow ravine in the hills. Great rugged masses of scoria were adhering to the sides of the ravine, as if a furnace had poured molten iron down it. Erosion had removed the lower portion of the lava, and bitten into the sandstone forming the bottom of the ravine. Following up the ravine for about a mile into the hills, the lava stream became more continuous, and appeared eventually to issue in a huge semicircular, bulging mass, from the top of a hill of very steep, smooth outlines. This hill, with all the surrounding hilltops at this level, for a circular area of about a mile in diameter, is composed of, or covered with grey "lapilli," little pebbles of scoria mixed with fragments of shale and red sandstone, from the size of a pea to that of a hen's egg, shot up by the explosive steam from the throat of the volcanic vent. These beds of "lapilli" appear to be of considerable thickness. At the top of the hill they seem to have been consolidated into a coarse stratified breccia, tipped up at an angle of 5 or 10 degrees on either side of the great mass of lava, as if the lava had broken through this portion of the crater and tilted up the brecciated sandstone in its exit.

Climbing over the lava mass, I stood on the top of the hill, and look down into a perfect oval-shaped crater, the bottom of which lay upward of 600 feet below me. The walls of the crater are of red Triassic sandstone, averaging 400 to 600 feet in the steeper part, whilst from the top of the lapilli-covered hills sloping gradually down into the steep throat of the crater, the hight was over a thousand feet. The crater may thus be said to be about one thousand feet deep. The bottom of the crater is oval and comparatively flat, dipping, however some five or more degrees to the south, that is, toward the side where the lava seems to have broken through and poured out. The diameter of the bottom is between 200 and 300 yards, the surface is covered with debris and sage-brush, doubtless overlying a solid plug of congealed lava. The width of the crater at its steeper portion, is between 500 and 800 yards. The sides are quite steep, having an inclination of from 45 to 75 degrees, and would be rather difficult to climb up or down. I did not make the attempt from lack of time. There is no natural exit or entrance to the crater. It is a complete cup. The red sandstone strata forming the throat dipped inwards at an angle of from 30 to 40 degrees, and appeared to converge toward the centre of the crater. Time only allowed me to make some rapid sketches and hurried observations, but from what I saw I think the following may be the history of this undoubtedly true crater and volcanic vent.

At some time, probably within the human period, eruptive forces found a vent at this point, and explosions of steam blew out a crater hole in the upper Carboniferous and Triassic strata. That the action was explosive. I judge from the great quantities of lapilli and comminuted fragments of shale and sandstone covering the surrounding the hills. The steam descending as water worked up some of the lapilli into a stratified breccia around the rim of the crater. When the explosive energies, that had filled the sky with steam and lapilli, descending in showers upon the surrounding hills, had subsided, a volume of lava arose in the throat of the crater, and poured out over the lip on the south side, partly breaking through the crust of breccia, and tilting it up as it passed through it. From the lip of the crater it poured rapidly down the steep face of the hill, and thence down the narrow ravine into the open valley, where it spread out as a cake of lava over the meadows and on to the river which it may have temporarily dammed back. The course of the lava was finally checked by coming against the abrupt cliff forming the south bank of the Eagle.

or the water of the stream may have checked the progress of the lava by congealing it. The character of the lava sheet, scoriaceous and vesicular above and below, massive and compact in the middle, corresponds to what is observed in modern lava flows. The surface of lava in contact with the air or water, gives off its imprisoned steam through multitudes of little steam holes. This reduces the surface of the sheet to a rough, spongy, vesicular mass, whilst the liquid lava flows on below. The same occurs with the under surface in contact with the cool or damp ground. Portions also of the scoriaceous top surface fall off the end of the advancing sheet and are rolled underneath it. As the molten stream advances, the spongy or scoriaceous surface is broken up into clinkers which are rolled along on the top of the liquid stream, and become piled up in confused masses where there is any check or obstacle to the flow, such as the cliff and river in the present instance.

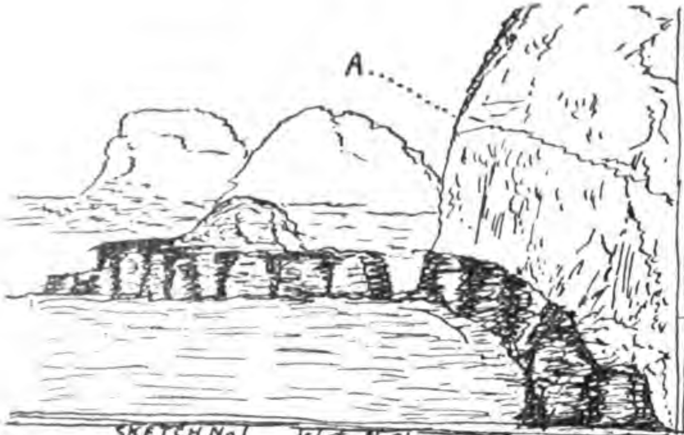
How comparatively old, or recent, may be the date of this eruption, it is not easy to determine. There are tall fir-trees growing in the throat of the crater. I did not see any sign of hot springs or gas emanations in the vicinity, such as are common in recently extinguished volcanoes, nor are volcanic rocks particularly abundant in the immediate neighborhood. This occurence seems to be an isolated one.

This interesting locality is accessible by the morning train of the Rio Grande railroad between Leadville and Glenwood. The lava flow is close by the track, but the crater is between three and four miles back to the north, in the hills. The blue grey color of the lapilli capping the hills can be distinctly seen from the train, and marks the locality of the volcano. A resort called Siloam Hot Springs has recently been established not far from this spot and would make a good stopping place for some geologist to more leisurely and thoroughly examine this interesting locality.

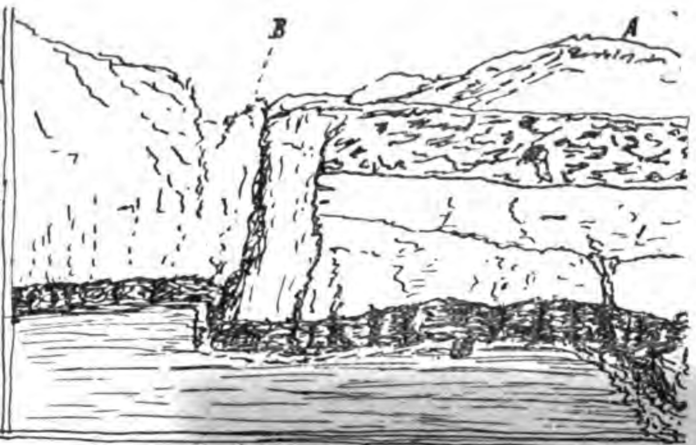
NOTES ON THE GEOLOGY AND SCENERY OF THE ISLANDS FORMING THE SOUTHERLY LINE OF THE SANTA BARBARA CHANNEL.

By Dr. Lorenzo Gordin Yates, Santa Barbara, Cal.

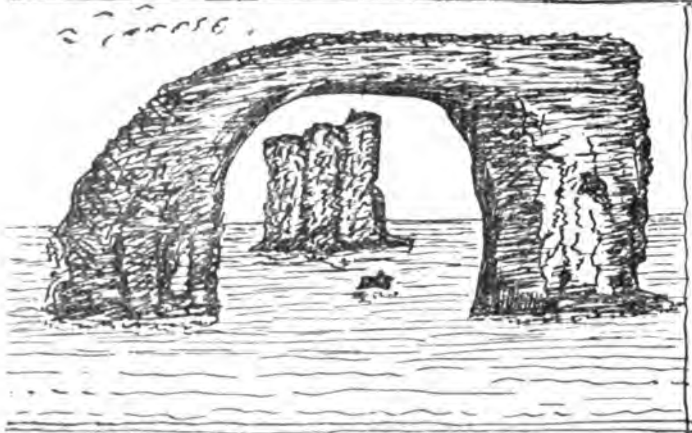
The entire group or series of islands, forming the southern line of the Santa Barbara channel off the coast of southern



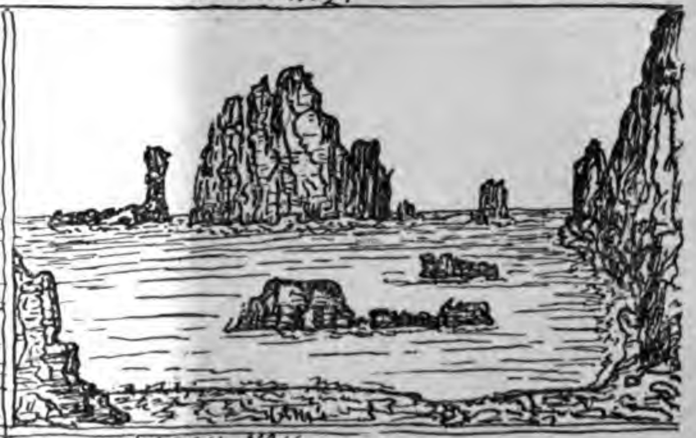
SKETCH No 1 Islet, N. Shore of Anacapas
Showing Black Basalt capped by Trachyte



Sketch No 2.



SKETCH No 3. EASTERN EXTREMITY
of Anachapas



SKETCH No 4.
S. Side of Anachapas.

California, from the San Miguel off point Conception to the eastern extremity of the Anacapas, is composed of a foundation of black vesicular basalt, upon which rest the later formations of trachyte and other varieties of volcanic rocks.

In many places the older flow of lava has evidently been broken up into irregular fragments, and cemented by the subsequent flow of intrusive lava, which formed a softer rock than the older basaltic formation; hence where this volcanic breccia is exposed to the action of the atmosphere, the intruded cement has disintegrated more rapidly, than the included fragments of the older formation, thus freeing the enclosed fragments which form the debris at the bases of the perpendicular cliffs along the shores of the islands. At other points,(for example see sketch No. 1 on north side of the middle Anacapas) we see the black basalts forming the foundation of the inlet up to about 20 feet above the surface of the water; the soft trachytic rock which formerly covered the basalt, has been eroded, leaving only a rounded elevation in the centre. A short distance from this islet the foundation is capped by a variety of irregularly stratified rocks; First, by a gray basalt; then by a lighter gray; then a dark line of much weathered trachyte, finally, by a light colored greenish gray stratified deposit which forms the present surface of the island.

This formation is shown in sketch No 2, where is also shown a wall of intrusive rock of a dark rusty color, capped by a warm grayish brown. This interesting exposure can be favorably studied from point Lookout, (A. sketch No. 1); which point may be reached by following a well made trail starting at the settlement and following an easterly direction, skirting the northerly line of the uplands, gradually tending downwards until a point is reached from which an excellent view of the west island may be had, also of the natural arches and entrances to the caves,—and higher up in the bluffs of the small wind-worn caves, the varied points and irregularities of outline, the wealth of coloring of rocks, plants, ocean, sky, and even the sea-weeds adding no unimportant item to the panorama.

As seen from this elevation the colors of the clear, calm water of the ocean shade off from bright yellowish brown and brilliant green at the surface, to the depths where the darker hues of brown and green are blended. Even the molluscs

Trochiscus norrissii on the kelp, seem to catch and intensify the colors of their surroundings. Almost directly under us lies the small islet shown in sketch No. 1.

Following the trail a short distance farther we round the point where the north side of the eastern island comes into view, presenting with the eastern portion of the middle island an entire change of color and outline. The shore line is of all shades of brown and green. The black basaltic base, with its overlying masses of trachytic rock of various colors, is weathered out into innumerable cavities and miniature caves. The outlying islets are viewed at an altitude of perhaps 200 feet above the ocean, which lies almost directly under our feet. The barking sea-lions and seals impress us with the idea of distant voices of human beings. The scene has a beauty and grandeur impossible to describe or imagine, and well worth the trouble it costs to reach the locality.

Retracing our steps we regain the higher ground and reach a point on the top of the greenish gray sedimentary deposit shown in sketch No. 2 at A. From this point we see the entire length of the eastern island, and the sinuosities of its southern side; the whole length of the southern exposure shows perpendicular cliffs from the shore to the top of the island some three or four hundred feet high, with the eastern end of middle island and the gray deposit before mentioned in the foreground, and over which at a low point marked "B" in sketch No. 2, we see the shore line of the eastern island, the peculiar form of which resembles the rim of an immense crater, a greater portion of whose circumference has been destroyed by the ocean which is continually battering at both sides of the remainder, which must, at a time not far distant, succumb to the forces of nature which are rapidly disintegrating the remains of what once formed a large extent of country.

The Caves.

Many of the caves on these islands are interesting, one of them which we called Freshwater or Indian cave, shows evidence of having been inhabited by the aborigines for a long period. At the mouth of this cave is a spring of good water seeping from the rocks into basin-shaped cavities which are evidently artificial. One of these fills up at the rate of 70 gallons every 24 hours. Among the refuse matter deposited in this cave by the Indians we found but little except some fragments of ropes made of sea-grass. Some of these ropes were braided with three strands,the others twisted like ordinary rope used at the present day. We found also bones of a variety of animals which had been used as food.

The largest cave on the Anacapas into which we rowed our boat consists of a chamber of about 400 feet in width, running back about 150 feet from the arched entrance, with a dome-shaped roof perhaps 100 feet high, rising from the circumference in a regular curve to the center. The floor of this cave is covered by water, and edged by a pebbly beach which extends around the interior, upon which we landed. Another which we called the Dark cave, is in the shape of a long gallery just about large enough to admit a small row-boat, but extends for some distance. It is divided into three distinct chambers, the openings between being so small that we had to bend over in order to pass through. The interior was so dark that, although we had two candles burning we could only tell where the walls were by alternately bumping our heads and elbows against them.

In passing along the bluffs in which the caves are situated, they present a panorama of unique and beautiful scenery, where the richness of color and peculiarity of outline are unequaled at any other point, the water for a great portion of the distance being perfectly calm, and so transparent that the flora and fauna of its depths may be as easily studied as upon the surface; bright orange-colored fishes darting in and out among the dark green sea-weeds, the shells, corallines and other inhabitants of the deep can there be studied in their native element.

The passing of every point opens up a new view in kaleidoscopic succession of picturesque beauty; steep weather-worn faces of perpendicular bluffs; deep fissures and wierd, mysterious caverns, from the tide-worn recesses of which issue the loud and continuous barking of seals; the undulating lines of flying flocks of brown pelicans; the ever changing colors of sea and shore, keep one continually on the lookout, that no portion of the interesting panorama be missed.

The interest increases until it culminates on reaching the Grand Arch at the eastern extremity of the group (see sketch

No. 3), where from a distance we may study the manner in which the islands have been encroached upon by the ocean.

The line of the surface of the eastern extremity of the group, and the tops of the outlying rocks, evidently formed portions of the same original slope, through which the sea made openings or passages which in time caved in from the top and formed distinct islands and outlying rocks still projecting above the surface of the water.

In this manner the islands have been broken through at the weakest points, thus dividing the Anacapas into three distinct islands; and the channels between the principal islands of the chain have doubtless been formed in the same manner.

The middle and eastern Anacapas are composed entirely of volcanic rocks with the exception of a superficial deposit of water-worn pebbles and fragments of quartzose and metamorphic rocks extending diagonally across the top of the middle island near its southeasterly corner, and from which the aborigines selected material for the manufacture of their weapons. Many of these fragments show evidence of having been broken and flaked off by the hand of man.

At a point on the south side of the island there is a deposit of limestone a few feet below the surface. Another deposit of drift occurs at the easterly end of the west island; a vein of milky chalcedonic quartz of about 10 inches in thickness is seen some 15 or 20 feet below the drift near the arched passage or "Natural Bridge" near the east end of the west island.

Westerly from the latter point this stratified uplifted rock rises abruptly until it attains a hight of almost 1,000 feet, with a dip of 45 degrees toward the north. This portion of the island was not explored to any extent, except as we rowed or sailed along the channel side where the bluffs rise perpendicularly from the water. At the beach near the "Natural Bridge" the prevailing rock is an amygdaloid and vesicular basalt containing spherules of zeolites.

The basaltic base of the middle island is composed largely of black vesicular basalt, containing spheroid and amygdaloid pebbles of chalcedony, which weather out and roll down the banks in the form of marbles. Some of these are solid, others are hollow and lined with drusy quartz.

Santa Cruz.

I had intended to make an examination of the island of Santa Cruz, but was refused permission to land for that purpose, by the Santa Cruz island company, so that I can only give notes on some widely separated localities; but as Prof. Goodyear of the state survey spent some time on that island last spring, we shall learn something of its geology from the published reports of the survey.

At Smugglers' harbor, near the southeasterly extremity of the island we found an interesting exposure, where the basalt, volcanic breccia and white bituminous shale may be seen in juxta position, the shale twisted and contorted by uplift of the underlying rock; the breccia composed of irregular fragments of vericular basalt cemented by trachytic cement.

Twenty-five miles from Smugglers' harbor, at the northwesterly extremity of Santa Cruz, Forney's cove affords a safe and convenient harbor, protected by a narrow neck of basaltic rock extending southerly from the main island.

From Forney's cove we follow the coast of the island, composed of perpendicular basaltic rocks similar to those of the Anacapas, to Lady harbor; just before reaching which we visit a beautiful cave with three openings, one towards the west, one towards the south into which the water of the ocean extends some distance affording a good landing on its pebbly beach; the other opening towards the east at the mouth of a wooded cañon which from this point rises rapidly towards the high mountains which are here but a short distance from the north shore. The westerly opening of this cave is exquisitely beautiful, the large arch and roof showing the minute details of the conglomerates, the irregular fragments of which lie scattered about, and project from the cementing material from which they are continually weathering out, leaving a ragged surface among the projecting points of which Polypodiums, Penstamons, and other interesting plants flourish in the greatest luxuriance. I have never seen such a magnificent growth of Polypodiums elsewhere as I saw fringing the mouth of this beautiful cave.

Santa Rosa.

The longer axis of Santa Rosa island, as also of the other Channel islands is parellel with the coast and the Santa Ynez range of mountains.

Its general outline is in the form of a parallelogram, its greatest length about 18 miles, and greatest width about 12 miles, with a shore line of nearly 45 miles.

On the northeastern side of the island and midway between the north and west points a reef extends out to a distance of one and a quarter miles.

The channels between this island and Santa Cruz on the east, and San Miguel on the west are respectively six miles and four miles in width.

The outline of the island is bold and no harbors exist around its shore, but there are several good landing places, and a wharf has been built about the centre of Five-mile bight, where vessels can load and unload in safety.

This island had been described as composed of sandstone, but the first thing noticeable on landing at the west end of the island was the volcanic character of the rocks.

At the wharf we found a good exposure of strata forming cliffs about 30 feet in hight, the lower portion, for 15 feet above the sand of the beach, composed of stratified sandstone, fine grained and destitute of fossils, with an occasional stratum of breccia or conglomerate. These strata have a dip of about 12 degrees southeast. The upper portion of the cliffs consists of a horizontal deposit of fragments of rhyolite, trachyte, vesicular basalt, and white bituminuos shale. The fragments gradually decrease in size from the bottom where they are cemented together by volcanic sand; this is covered by deep and apparently good soil.

In some places the rock fragments of the upper half of the cliffs have been water-worn and form conglomerate.

This character of rock extends from the wharf southeasterly to near the sand point at the southeastern extremity of the island, where it culminates in a hill of volcanic rock 175 feet high, which is exposed for some distance in a southeasterly direction from the beach on the north side of the point.

The rocks have a marked tendency to weather into fantastic forms, the angular rocks becoming rounded by disintegration, with irregular cavities and caves worn by the winds which have been used as dwellings by the aborigines as is indicated by fragments of shells and other debris in large quantities.

At the northeastern extremity of the island is found a coarse volcanic breccia, composed of porphyritic and trappean rocks, having a distinct stratification with a dip of 30° southeast.

Several spurs extend out some distance from the shore line and others have been worn away by the surf until they form small rocky islets, while the porphyritic rocks, which have weathered out of the breccia, lie as smooth bowlders at the base of the cliffs.

From this point the hills rise sharply to a hight of from 250 to 300 feet, and run southeasterly to the main backbone of the island which lies on the line of its longest axis.

The highest points on this range were visited, and the altitude was found to approximate 1,400 feet.

Several high peaks are grouped together about five miles south from the wharf, being on the northern side of the line of the long axis of the island.

Three of these high peaks lying within a mile circuit were measured, the first, Black mountain, indicated a hight of 1,325 feet; crossing from this peak over a depression of 350 feet below the first summit we find rhyolite and white bituminous shale. The next peak south, (Saddle mountain) is about 100 feet higher than Black mountain.

Between this point and the hills on the southeastern side of the Cañada de la Cruz (Cañon of the Cross), we found limestone in the bed of the creek, together with fossil oysters (Ostrea titans) and other Miocene fossils. Southeasterly from Saddle mountain, and lying between Cañada de la Cruz and the ocean there is an intrusion of syenite, the extent of which has not been ascertained, nor did I discover the line of junction between the Miocene and Pliocene.

On the north side of the island, about ten miles from the wharf, near the mouth of Saledad Cañon, we found an excellent exposure of strata, consisting of about 90 feet of Post Pliocene deposit, containing fossil bones of vertebrates, and at one place, fossil Physas, (P. d'orbigniana), at a depth of some 75 feet below the surface.

This deposit is horizontal and overlies strata of older rocks, probably Pliocene, which dip 13° N. E. and contain Pecten, Turbinella cæstrum, and Hinnites giganteа in abundance, and in an excellent state of preservation.

From this point to the southwestern extremity and around the west end of the island to the point where the main range of mountains meets the ocean, the shifting sands have covered the rocks. There is no indication of drift on Santa Rosa island, hence we cannot account for the presence of the fossil elephant on the theory of its having been brought by floating ice, as advanced by some writers. It will be observed that the Anacapas Santa Cruz; Santa Rosa and San Miguel islands are on a line with point Dumas on the east and are parallel with the Santa Ynez mountains as before stated; at this point the islands were doubtless once connected with the main land, and what is now the Santa Barbara channel was then a gulf or arm of the sea, beginning at point Conception and running in a southeasterly direction for, say 150 miles.

When these islands were thus connected with the mainland, it was easy for them to become inhabited by the larger vertebrates.

It is also probable that this chain of islands is a portion of the same outflow of lava which formed the volcanic ridges and peaks on the mainland east of them.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

North American Geology and Paleontology. S. A. MILLER, Cincinnati. The author, pp. 664. This work was announced in this journal, vol. IV, p. 255. Its figures, illustrative of fossil species, number 1194. They are distributed alphabetically through the paleontological portion of the book. In brief the work is a dictionary of North American paleozoic paleontology, giving the names of all genera and species, their formations, authors, dates and where published, with illustrations when necessary or when available. It is a work which no paleontologist can well be without, and displays a vast amount of patient and careful labor. It is introduced by a brief discussion and definition of the laws of geology and geologic nomenclature, specially describing the systems and groups to which the author makes assignment of paleozoic fossils, and it is finished by a glossary of specific names in use in North American paleontology, giving their signification, and by an index of genera.

Some peculiarities appear in the opening geological chapters. 1. The author has positive opinions and is fearless in the statement of them. 2. The term Cambrian is not employed, but the term Silurian is made to cover the interval where Cambrian was placed by Sedgwick. 3. The term Taconic is made to embrace the most of the primordial zone, omitting only the Dikelocephalus horizon. 4. The Quebec group he considers "very doubtful." He makes the Oriskany the base of the

Devonian, and a coarsely fragmental sandstone or conglomerate the base of each of larger sub-divisions, after the plan of Dr. J. S. Newberry. 5. He does not classify the Comanche series as the base of the Cretaceous nor mention it at all. 6. He scouts the idea of a glacial epoch, saying "Indeed there is no evidence a glacial sheet ever existed on any part of the continent; none that gives any warrant to the hypothesis of a glacial period. * * * * The scratches and furrows are readily accounted for without the hypothesis of a glacial period. * * * The glacial epoch is a theoretical blunder, not supported by scientific facts or intelligent reasoning, and contrary to all geographical, geological and paleontological information. There is no such geological period, and no gap into which it can possibly be injected."

A dictionary of the fossils of Pennsylvania. Compiled by J. P. LESLEY, state geologist. Harrisburg, 1889. Report P^4. A to M.

Prof. Lesley has been able, after an almost unlimited amount of work, to present to the public a really good dictionary of fossils, which will be highly appreciated, not only by the "quarrymen, prospectors, etc.," but by the scientific reader.

The fossils are arranged alphabetically, which, although useful to the more scientific reader, is not readily available for the general public; while Prof. Lesley's method is undoubtedly the best one, still for the benefit of the general public it seems to me that it would have been better to have added a list of counties, then the localities in each county, giving only the name of the fossils there found with the proper page reference to the more descriptive alphabetical list, thereby making the book more readable to this latter class. The book is profusely, though not at all times *well* illustrated, some of the cuts being rather coarse.

Not only has Prof. Lesley given the Pennsylvania fossils, but those also from the same horizons in the neighboring states, thereby making the book all the more valuable.

In his letter of transmittal to the governor, Prof. Lesley attacks (mildly to be sure) the theory of the evolution of forms by saying—"that they (the readers) can not find a single proof, however slight, for the actual hereditary descent of living creatures of our age from those of preceding ages"—this, however, applied to this portion of the work is *fairly* satisfactory from the fact that the book deals mainly with the invertebrates and the evolutionists *strongest* proofs are as yet in the vertebrata. Nor do the evolutionists claim an unbroken succession of life.

With the exception of the few bad wood-cuts, the work is up to the standard of the former publications of the Geological Survey and it is to be hoped that Prof. Lesley will be able to complete the second part without being delayed (as he was with the first part) by the printng of valueless legislative documents.

Report on the landed property of the Buena Vista company. By W. H. RUFFNER. 8vo, one map, pp. 104.

"Buena Vista is in the great valley which extends from Canada to Alabama, and which is noted for its limestone lands, iron beds, clear streams, healthful climate, picturesque scenery, the number of its towns and its substantial population. The valley is known in Pennsylvania as the Lehigh, Cumberland, etc., where it abounds in natural resources and acquired wealth. In northern Virginia it is the Shenandoah valley. In the middle it originates the James and the Roanoke rivers. Southward it is known as southwest Virginia, where now is in progress a remarkable scene of industrial development."

While this is essentially an economic report, its descriptions, based on a comprehensive knowledge of the geology of the region, give an accurate and valuable account of its iron ore beds, clays, ochres and sands, and of its limestones, cements, water power and general agricultural capabilities. For its scope it is a model popular geological report.

Development of some Silurian Brachiopoda. CHAS. E. BEECHER AND JOHN M. CLARK, Albany. *Mem. N. Y. State Museum*, vol. I, No. 1, 4to, 8 plates, pp. 95.

This is a valuable addition to the science of the brachiopoda. It indicates the developmental changes in the life-histories of twenty-five species, some of them with great fulness, and makes known the dangers that surround the paleontologist who publishes new names for small variations in form. The plates are very instructive, and ought to be imitated in the treatment of other genera.

The authors have made use of the very abundant material afforded by collections from Waldron, Indiana, to trace the individual development of all the species of brachiopods known from the Niagara shales in that interesting locality.

To give some conception of the amount of material at their command it is stated that the collections when received weighed about seven tons. After specifically separating the mature specimens and all that were approximately mature, some fifty thousand immature individuals for the most part less than five millimeters in length, were gathered from the washings of the slabs. The result is that for a large proportion of the brachiopod species the authors are able to show a series of individuals beginning with forms in some instances less than a millimeter in length and including every stage of growth up to the aged adult with its greatly thickened margin and crowded lines of growth. Some of the rarer species have afforded no young specimens, while among the really common forms, *Rhynchonella stricklandia* and *Whitfieldia (Meristina) maria* are particularly remarkable for the absence, or almost entire absence, of immature individuals.

"The method of illustration which has been adopted is one which seems most readily to furnish a means for comparison of characters. The embryonic shells are represented as enlarged, usually to the size of an adult, and accompanying the enlargement are natural size presentations of the final result of normal growth. Where the mature forms have been too minute to show satisfactorily the details of structure, both the developmental stages and full grown shell have been enlarged to a convenient size. Thus the incipient stages and mature specific forms are presented together."

Among its facts of interest brought out by the investigation here referred to is that the initial stages of very distinct species, and even of very distinct groups, are so much alike, that it is often impossible to say whether a given embryo is the young of *Spirifer*, *Athyris*, *Rhynchonella*, *Anastrophia*, *Meristina* or *Nucleospira*. The conclusions of the authors, however, do not admit of any condensed statement and persons interested in the subject are referred to the original paper.

Report on the geology of the Rainy lake region. By ANDREW C. LAWSON, Ph. D. (Part F of the Annual Report of the Geological and Natural History Survey of Canada for 1887.) pp. 190, with two maps, 7 sections, 7 plates from photographs, and 15 cuts in the text illustrating the microscopic features of thin sections of rocks. Montreal, 1888.

In this approximately plain or moderately hilly Archæan region, so thinly covered by the glacial drift that often the bed-rocks are exposed to view almost continuously along distances of many miles, exceptionally favorable opportunity is afforded for their study. But the uninhabited condition of the country (forest and swamp, without roads) permits extensive travel only by canoes and by portages across the narrow divides between lakes at the head of the stream-courses.

The Archæan group there is found to be divisible into two systems, the lower being the granitoid gneisses, to which the name Laurentian is restricted by Dr. Lawson, and the upper being chiefly schists, which are again divided into two series. The older of these, consisting of mica schists and granitic gneisses, with a measured maximum thickness of four or five miles, is named by Lawson the Coutchiching series, well developed about Rainy lake; and the newer, including metamorphosed volcanic rocks, with schists, greywackes, quartzytes and slates, he has called the Keewatin series in a former report on the region about the Lake of the Woods. The present report gives very abundant and interesting observations of these formations, and ably discusses their origin and age, the history of their metamorphism, and their present structure and relationship.

The author's studies lead him to believe that after the deposition of the stratified formations which constitute the upper part of the Archæan in these districts, the whole group comprising a vast thickness of sedimentary and volcanic rocks and perhaps below including a part of the first formed crust of the globe, was subjected to metamorphism from the heat of the earth's interior, whereby the basal Laurentian rocks were so fused that portions of them were extravasated through the overlying Coutchiching and Keewatin series. The Laurentian system can there be classified only on a petrographical basis, as its distinctions of stratigraphical sequence and relationships, if any such ever existed, have been obliterated. All the characters of these gneisses indicate, according to Dr. Lawson, that they are plutonic rocks which have crystallized slowly, probably under an extremely gradual diminution of temperature, from a thickly viscid, coherent or tough, hydrothermal magma. Up to the time of its final solidification, when it became approximately rigid, it appears to have been subjected to differential pressures, which, by causing a yielding or deformation, induced a flow in the mass, with the results of its foliation as gneiss and the parallel alignment of inclusions of foreign rock imbedded in it.

Parts of the overlying Coutchiching or Keewatin series may also have been involved in the fusion of the Laurentian floor, becoming thus indistinguishable from it. Above the upper limit of fusion these overlying beds are supposed to have retained their stratification and to have rested as a crust of hard and brittle rocks upon the magma, subject to its metamorphosing influences. Fragments of the upper Archæan schists sank into the molten Laurentian, often to great distances from the contact, and the fissures and crevices of the schists were filled with injections of this magma, which crystallized eventually as the Laurentian gneisses, attaining its present rock structure later than the overlying series. In mapping these systems, it is discovered that the Laurentian gneisses and granite occupy large roundish areas, isolated by encircling belts of the upper schists, much as the Archæan rocks of New Hampshire were mapped by Prof. C. H. Hitchcock in the geological survey of that state.

Drift is spread thickly over the country southwest of the Lake of the Woods and Rainy lake, but on the north and northeast it is scanty, and the bed-rocks have been everywhere rounded, grooved and polished by the ice-sheet, the average direction of its movement being S. 40° W. The distribution and character of the drift deposits are explained in part by the former presence of the glacial lake Agassiz, held in on its northeast side by the barrier of the receding ice. Abundant rock-outcrops and intervening swamps render the greater part of the region unfit for agriculture, excepting a tract about fifteen miles wide along the Rainy river.

Metamorphism of rocks. A. Irving. Longmans, Green & Co., London and New York. 8vo. pp. 137. 1889.

In this decidedly technical and learned treatise the author starts out by stating the exact points to be investigated, the difficulties of present theories and the inadequacy of the term "metamorphism" to convey a definite idea of any particular change in rocks. He uses the term metamorphism to indicate "only changes in the internal structure of rock-masses (i. e., in their morphology)," while changes in the external form and chemical changes, are denoted by the terms, Metatropy, Paramorphism and Metataxis. He defines them as follows: "1. Paramorphism, including all those changes within a rock-mass, essentially of the nature of chemical changes in which the original minerals have had their chemical composition more or less altered, while new minerals are formed within the mass. 2. Metatropy, or changes in the physical characters of rock-masses, while there is no essential chemcal change either in the rock-mass or in its constituents. 3. Metataxis, or changes of order of the constituents of the rock-mass, of which the phenomenon of slaty cleavage may be taken as a typical instance."

The author concludes that the Archæan rocks "represent upon the whole the primordial (first formed) earth's crust, from which the siliceous materials of the sedimentary rocks have been for the most part derived." But he does not consider these ancient crystalline rocks to be the first sediments and crystallized by hydro-thermal agencies. He believes there was a pre-oceanic stage during which a crust was formed which would theoretically consist of quartz and orthoclase as the Laurentian granites really do. This, he says, leads to the further conclusion that the process by which the Archæan gneisses and schists were formed (so far as their essential mineral characters are concerned) was essentially 'diagenetic' rather than 'metamorphic.' If this be admitted such phrases as 'the highly metamorphosed Archæan gneisses and schists' must be relegated to an obsolete nomenclature of geologic science."

The various phenomena of regional and contact-metamorphism are discussed and some of the causes assigned or suggested as possible explanations of them are interesting to say the least. An instance is in regard to foliation. He says, "we *may* come ultimately to associate the feeble foliation of the fundamental gneiss where it has not been interfered with by mountain building processes with the earlier *solar* tidal waves and the more pronounced foliation of the Archæan schists with the subsequent *lunar* tidal waves of the magma."

Although we may not agree with Mr. Irving in his conclusions we can not fail to read with interest his reflections upon "metamorphism," which interest is heightened by the suggestiveness of many of his undeveloped ideas.

Geology of Colorado ore deposits. By PROF. A. LAKES. The scope and purpose of this little volume of about 150 pages can be best expressed in the language of the author, "This treatise contains the substance of a series of elementary lectures delivered by the author to the students of the Colorado State School of Mines. It is published with a view of meeting some of the needs of the general public, of the ordinary miner, and of the unscientific many, rather than with any idea of offering original matter for the discussion of the scientific few."

In carrying out the purpose as above set forth, Prof. Lakes gives a succinct account of the successive geological formations, illustrating this part of the subject when practicable by references to outcrops and exposures of the successive strata within the limits of Colorado.

The most valuable part of the work deals with the distribution and modes of occurrence of Colorado ores. The lithological characters and geological age of the rocks in which ores are found are very fully discussed. The intelligent miner will find much valuable information respecting the characteristics and origin of placers, the origin of veins, lines of contact where minerals may be looked for with probable success, and other matters such as faults, dykes, etc., of equal interest and importance. There is reason to believe that mines and mining are regarded with more favor in Colorado than researches in paleontology. At all events the references to fossil faunas are not always happy. For example, in speaking of the well known Carboniferous brachiopod, *Spirifera rockymontana* Marcou, there seems to be an unnecessary concession to unscientific readers at the expense of scientific accuracy when it is described as "a sort of pectinated cockle-shell with a groove down the middle of the shell; this is called a Spirifer (Spirifer Rocky-Montana)." *Pleurotomaria* is in one place transformed into Pleuroto-Maria, while a little farther on, as if in expiation of previous reckless waste of capitals, the genus *Inoceramus* is written with a small i.

On the whole, however, the work is a valuable one, and Prof. Lakes has rendered his fellow-citizens an abiding service in giving them a guide to the geological structure of Colorado and the distribution of its important mineral deposits at once so clear, so thorough and so reliable. Even the "scientific few" will find in it much to interest them. The work is finely illustrated with views, sections, etc., from the facile pencil of the author.

Description of eight new species of fossils from the Cambro-Silurian rocks of Manitoba. By J. F. WHITEAVES. This paper constitutes a part of Transactions of the Royal Society of Canada, vol. VII, Section IV, 1889. Of the eight species here described, one is a gastropod, *Maclurea manitobensis.* The other seven species are Cephalopods. The *Maclurea* is one of the finest examples of the genus, some individuals attaining a diameter of eight and a half inches. Although the exact stratigraphical relations of the rocks from which the fossils were obtained have not been determined, they are yet on purely paleontological grounds referred in part to the horizon of the Trenton limestone and in part to the Hudson River group. The Cephalopods taken by themselves, however, would certainly indicate a later period than any to which the species in question have been referred. Parallel generic differentiation did not occur among Cephalopods in the Mississippi valley until the late Silurian or early Devonian. Six plates illustrate the paper.

The Geological and Natural History Survey of Minnesota, Seventeenth Annual Report, for the year 1888. N. H. WINCHELL, State Geologist, pp. VIII and 270. The main body of this report is divided about equally into three parts, the first being a discussion of the stratigraphy of the Archæan and primordial formations by the state geologist, the second a report of field-work in the Archean iron producing district of northern Minnesota by Mr. H. V. Winchell, and the third a report of field-work on the Archean of northeastern Minnesota by Mr. Uly. S. Grant. There follows a bibliography of American publications since 1872 relating to the crystalline rocks of the Northwest, occupying thirty-three pages.

Professor Winchell reviews the development of knowledge of the crystalline rocks of the state during the progress of the present survey, and points out some of the problems that need further investigation. He notes that the Archean group has been subdivided, sometimes into only two parts, but more frequently into three or more, which are accepted not only by the geologists of the Northwest, but by geologists who are at work on this group of rocks throughout America and Europe. In Minnesota six members of the group, if this Huronian be included in it, maintain a constancy of character and stratigraphic position extending into Wisconsin, Michigan and Canada, such that they require separate descriptions. But Prof. Winchell regards the Huronian as the equivalent of the Lower Cambrian of Sedgwick, instead of which, however, he would adopt the name Taconic, proposed for these rocks in New York by Emmons, referring to this series the Animike slates north of lake Superior.

The Laurentian rocks of the Canadian geologists are divisible, as shown by Prof. Winchell's observations in the Minnesota survey, into three parts, having different genesis and age. They are here described as "partly the result of change *in situ* from old sedimentary strata of Laurentian age, and partly the result of eruptive forces which have caused an extrusion and partial overflow over later sedimentary strata of some of the fused materials of the same old strata. Such extrusion has taken place at least at two epochs. * * * " Under this view the name Laurentian ought to be applied only to the first of these parts, which is the fundamental gneiss; and the eruptive masses originating from it are of subsequent age, as Vermilion, Keewatin, Animike, or later, to be determined by their relationship with these series overlying the true Laurentian.

Next above the gneiss is the great series of crystalline schists named Vermilion by Winchell in 1886 and Coutchiching by Lawson. The former shows in this report that the Laurentian sedimentary age probably ended with a characteristically eruptive era, producing in some places an unconformable and elsewhere a conformable transition, such as have been observed, from the Laurentian gneiss to the Vermilion schists. There is again a gradual and conformable transition from the Vermilion to the Keewatin series,the latter having nearly the same characters as about the Lake of the Woods, where it was studied and named by Dr. Lawson, and the Keewatin period, according to Prof. Winchell, "closed by a renewal of active eruption as profound in its energy and its effect on the pre-existing strata as that which marked the close of the Laurentian." The vast deposits of iron ores, chiefly jaspilyte, which are mined at Vermilion lake, are included in the Keewatin series, but whether the jaspilyte was sedimentary or eruptive remains an unsettled question.

Much diversity of opinions has prevailed concerning the correlation of the primordial formations in Minnesota and the Northwest with those of the northeastern states. Professor Winchell denominates the lower three Northwestern divisions of this group in ascending order the Taconic, Potsdam, and Saint Croix series, referring the Keweenawan series of Irving to the Potsdam epoch. At the base of the Taconic a wide-spread unconformity is recognized, separating the Keewatin series, the uppermost of the Archean, from the Animike (Taconic) formation.

The Rivers and Valleys of Pennsylvania. By WILLIAM MORRIS DAVIS. pp. 71. (Lecture delivered before the National Geographic Society at Washington, Feb. 8, 1889, and published in the National Geographic Magazine, vol. 1, No. 3). The investigation presented in this essay was attempted with the hope of unfolding a teachable sequence of facts that would serve to relieve the usual routine of statistical and descriptive geography; but the author finds, after thorough study and analysis of the well determined geologic and geographic features of Pennsylvania, that the history of the Susquehanna, the Juniata, or the Schuylkill is too involved with complex changes, if not enshrouded in mystery to become intelligible to any but advanced students. To such the essay will be found very suggestive, opening a new field of geologic observation and induction. The single course of an ancient stream is now broken into several independent parts, and conversely the present rivers are often made up of parts that were formerly separated by watersheds. For example, the Juniata of to-day comprises headwaters acquired from Ohio streams, and the lake in which the river once gathered its upper branches has become a mountain-top, so that the streams now flow around the margin of the lake, not across its basin.

Preliminary to the special discussion of the development of the rivers of Pennsylvania, the author sets forth the general history which a river would pass through in its cycle of youth, adolescence, maturity and old age, on the supposition that a continental area were uplifted from the ocean and were then allowed to remain undisturbed through this period. But it may be doubted whether so long repose has ever been granted to any river basin; and manifold changes in the course and character of streams have been caused by movements of elevation, depression, and mountain-building.

Professor Davis finds evidence that the Appalachian mountain system as it was originally upheaved in the Permian era has been greatly reduced and indeed finally worn away, while the ridges of to-day are merely the relief left by the etching of Tertiary valleys in a Cretaceous base-leveled lowland. He therefore concludes with Powell, that "mountains can not remain long as mountains; they are ephemeral topographic forms."

The most conspicuous proof of differential elevation or subsidence during the Tertiary era are the wind-gaps in the long mountain ridges, of which the one best known is the Delaware wind-gap between the Lehigh and Delaware water-gaps in Blue mountain. This wind-gap marks the unfinished notch cut by some stream whose headwaters have since been diverted, probably to the Lehigh.

The Structure of Drumlins. By WARREN UPHAM. (From Proceedings of the Boston Society of Natural History, vol. XXIV, 1889, pp. 228-242). The most important part of this paper describes sections of the drumlins that form Third and Fourth cliffs on the coast of Scituate, Mass., about twenty-five miles southeast of Boston, consisting of till on the surface and to a depth of 15 to 25 feet or more and a central mass of modified drift, beds of gravel, sand and clay, with arched stratification. The bedding of the modified drift, and the obscure lamination which is commonly a characteristic of the till and is distinctly seen there, are parallel with each other and conformable with the line of division. No evidence of erosion, nor of tumultuous pushing forward, was observed; but instead these sections appear to represent continuous deposition. The author believes that these drumlins, and probably the other drumlins so well developed upon many areas in the vicinity of Boston, were accumulated rapidly beneath the ice-sheet and near its receding margin at the close of the glacial period.

RECENT PUBLICATIONS.

1. *State and Government reports.*

On the form and position of the sea-level. R. S. Woodward. Bul. No. 48, U. S. Geol. Sur.

Latitude and longitude of certain points in Missouri, Kansas and New Mexico. R. S. Woodward. Bul. No. 49, U. S. Geol. Sur.

Formulas and tables to facilitate the construction and use of maps. R. S. Woodward. Bul. No. 50, U. S. Geol. Sur.

On invertebrate fossils from the Pacific coast. Charles A. White. Bul. No. 51, U. S. Geol. Sur.

Subaërial decay of rocks and origin of the red color of certain formations. Israel C. Russell. Bul. No. 52, U. S. Geol. Sur.

The geology of Nantucket. N. S. Shaler. Bul. No. 53, U. S. Geol. Sur.

3. *Papers in scientific journals.*

Am. Jour. Sci. Dec. No. The lower Cretaceous of the southwest and its relation to the underlying and overlying formations. Chas. A. White. Hinge of the pelecypods and its development, with an attempt toward a better subdivision of the group. Wm. H. Dall. Relation of the uppermost Cretaceous beds of the eastern and southern United States. Robert T. Hill. Tertiary-Cretaceous parting of Arkansas and Texas. Robt. T. Hill and R. A. F. Penrose, Jr. A description of several Yttria and Thoria minerals from Llano county, Texas, W. E. Hidden and J. B. Mackintosh.

CORRESPONDENCE

Letter from M. A. Michel Lévy. *Monsieur:* Je viens de récevoir votre aimable envoi, et je m' empresse de vous en remercier cordialement.

Je vous suis reconnaissant d'avoir fait connaitre au grand public qui s' interresse, en Amérique, aux choses scientifiques, que la science allemande n' existe pas seule, en matière de travaux pétrographiques. J'appelle de mes voeux le moment òu le langage pétrographique pourra être unifié, grâce à des concessions réciproques, et en cherchant un appui sûr des faits contingents, indépendants de toute hypothèse. A ce point de vue, je pense que vous avez rendu service à la science en faisant connâitre mes objections à la classification par trop théorique, adopté par Rosenbusch, et suivie actuellement par les nombreux adeptes de la puissante école.

Croyez, cher monsieur à mes sentiments reconnaissants et devoués.

Paris le 16 Novembre, 1889. A. Michel Lévy.

Monsieur Alexander Winchell. 26 rue Spontini à Paris.

The fossils of the Trinity beds. Pardon me for entering a mild protest against the revision of the species from the Trinity beds of Arkansas, published in your last issue from the pen of my esteemed friend Mr. Jules Marcou. The Pleurocera is neither a Nerinea nor a Cerithium, nor have any of the numerous specimens shown "the opening with a fold so common to the Nerinea," but upon careful examination of many specimens no such folds are apparent. What Mr. Marcou *mistakes* for a fold is a fragment of stone. Neither is the Vivipara a Natica as shown in the excellent illustrations. I fear that Mr. Marcou has been a little hasty, as he will no doubt confess, if he examines the specimens. The fauna is estuarine and brackish, accompanied by sharp sands, lignites, clays, cross-bedding, vertebrates, etc.

Very respectfully,

Austin, Dec. 7, 1889. Robt. T. Hill.

PERSONAL AND SCIENTIFIC NEWS.

Prof. C. L. Herrick, Granville, O. has been Appointed professor of biology and geology in the University of Cincinnati, at Cincinnati, Ohio.

Prof. E. D. Cope has been Elected by the Trustees of the University of Pennsylvania to fill the chair of geology in the auxiliary course of medicine in that institution.

The Deepest Bore in the World, claimed at different times for a number of places is, according to the latest accounts, at Schladebach, a small German village near Leipsic. It measures 17.484 metres, or about 5.735 feet. The time expended in boring to this depth amounted to six years, at a cost of $52,500. A peculiar experience encountered in connection with this and other deep holes in different parts of Germany is, according to *Unland's Wochenshrift*, that the observed temperatures, while steadily increasing with the depths, show a smaller ratio of increase in the lower strata.

The Testimony of Professor Orton, the State Geologist of Ohio, given in a natural-gas case at Toledo, is not calculated to pull natural gas very far out of the slump in which it is. Natural gas, he said, is now a fixed quantity, its manufacture having ceased long ago. Hence the more that is taken out of the earth the less that remains to be taken out. With care and economy the northwestern Ohio field with the present draft upon it will last for from five to eight years, but not for ten, he thinks. Three years he gives as the average life of a gas well.—*Pittsburgh Commercial Gazette.*

Dr. C. E. Bessey,a well known Botanist, is acting chancellor of Nebraska State University, Lincoln; Dr. S. H. Peabody a zoologist, is chancellor of Illinois Industrial University, Champaign. These should be added to the list of scientists at the head of state universities given on p. 320 vol. iv of the Geologist.

Prof. Franklin R. Carpenter Resigned the Position of Dean of the Dakota School of Mines, at Rapid City, in November, and is engaged in some experiments in pyritic smelting, with an iron matte, which are said to promise important advantages to the mines in the Black Hills. The position vacated by Prof. Carpenter was filled by the appointment of Mr. Geo. F. Duck M. E., of Bethlehem, Pa.

Mr. W. P. Blake, Describes in the *Eng. and Min. Jour.* Dec. 21, another new bituminous mineral, and names it (from Dr. Henry Wurtz of New York) *Wurtzilite* It is from Wasatch county, Utah, not far from the source of the Uintahite, now an article of commerce.

"The new substance differs essentially from any hitherto described. It is a firm, black solid, a little heavier than water, and breaks with a brilliant conchoidal fracture, and has a general resemblance to jet or some of the cannel coals. It is sectile, cutting like horn or whalebone. The shavings and thin flakes, or fragments, have a degree of elasticity. These characters led, at first, in Salt Lake to the supposition and the report that the substance was allied to caoutchouc, or vulcanized rubber. But it was soon found to be without the essential qualities of rubber, not having tensile elasticity, and being very difficult of solution. It was then for a time referred to the species elaterite, the only elastic bitumen described in Dana's mineralogy. But a comparison of the subtance with the description of the assemblage of dissimilar substances classed under the name elaterite shows that it differs from either of them, and that it has much better defined characteristics, which permit a specific description and entitle it to a distinctive name.

Wurtzilite occurs in large, homogeneous masses, free from mechanical admixture and without any evidence of formation in layers, or of fusion. It is amorphous, and when cold, or at ordinary temperature, it is brittle and breaks with a large conchoidal fracture, giving very brilliant, glossy surfaces with a vitreous lustre like uintahite, and resembling in appearance the splendent conchoidal surfaces of newly-broken obsidian. It has, however, a degree of toughness which increases with an elevation of temperature, and it requires a quick, sharp blow to detach a flake and secure a good fracture.

Elasticity is observable in thin flakes, but this elasticity may be compared to that of glass or mica rather than to the yielding tensile elasticity of "rubber." If the flake is bent too far, or suddenly, it snaps like glass. The substance is also flexible and when slowly pressed and warmed a flake may be bent nearly double.

Color.—The extremely thin edges of the flakes obtained by fracture are garnet red by transmitted light, and are often brilliant. It would thus appear to be transparent in very thin plates, and to be deep red in color. The color of the mass by reflected light is a jet black.

Hardness.—The hardness is such that it is not impressed by the nail at ordinary temperature. It scratches gypsum, and does not scratch rock salt. It is thus between two and three in the scale of Mohs.

Specific Gravity.—at 60 degrees F., 1.03.

Fusibility.—Does not fuse in boiling water, but becomes softer and tougher, and is more plastic, but is not viscid or sticky, and fragments are not adherent. It melts in the flame of a candle, takes fire, and burns with a bright, luminous flame, with a slight crepitation and little smoke, giving off a strong bituminous odor. Fused in a glass tube it gives off a dense cloud of white and yellow smoke and distils over a thick brown, tarry oil with a strong odor, and leaves a small residue of fixed carbon. Fragments warmed in the hand emit a strong odor like that of some of the crude petroleums, which is rather offensive.

Electrical Properties.—It is a good electric. Negative electricity is easily developed by friction. It will be found useful as an insulating material and for other purposes in the arts.

Solubility.—It is not easily dissolved. It resists the usual solvents of bitumen, but experiments are in progress which will probably lead to a process by which it can be successfully worked in combination with other substances."

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NOTES ON A KANSAS SALT MINE.

By ROBT. HAY, F.G.S.A., Junction City, Kan.

The substance of a paper read at the Toronto meeting of the A.A.A.S., 1889.

In 1886 and 1887 there was much speculative boring in Kansas. Rock gas and some oil having been found in the eastern counties of the state, the people of the middle and west tried their luck with the drill. In August, 1888, it was announced that rock salt had been struck at Ellsworth, on the Smoky Hill river, west of the 98th meridian, and at Kingman, 75 miles south, just east of the same meridian. Which place struck it first is now a matter of dispute. At Kingman, Triassic 'redbeds' are on the surface, and the salt was found below them. At Ellsworth, the Dakotah formations are on top but the drill showed what had not been before suspected, that the redbeds there underlie the Dacotah. At several places between these, and also further south and west, and one place east, the rock salt was found and is now being manufactured by the various methods of evaporation.

At Kingman, however, through the indefatigable exertions of Mr. W. H. Child, a shaft was commenced on the 2nd of April, 1888, with a view of mining the solid salt. The shaft is 8ft. 2in. x 4ft. 2in., inside the casing. Early in April, 1889, salt was reached in the shaft. The first bed was reached at a depth of 782 ft. This seam was two feet thick. Then followed shale with vertical and other irregular seams of salt from 1 to

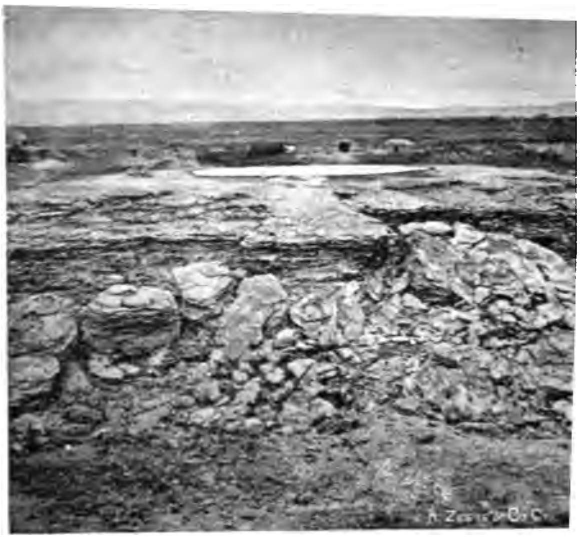
3 inches thick and then other salt beds, alternating with similar shales. One bed of 11ft. has been reached and the end is not yet.

The section of the shaft is of course of more value than the drill record, and we give it here as far as it has progressed:

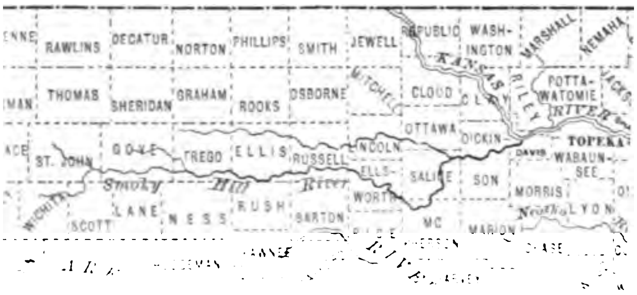
SECTION OF KINGMAN SALT SHAFT TO THE DEPTH OF 820 FEET.

"Red-beds"—Red arenaceons, limestones, ferruginous clays, and clay shales with thin streaks of gray shales and bands of gypsum as satin spar.	450 ft.
Gray or bluish "slate," with 2 ft. of limestone at 500 ft.	140 ft.
Red clay shale	4 ft.
Gray "slate," with occasional streaks of limestone, 2 to 8 in. thick, and some salt partings and satin spar with ferruginous stain.	78 ft.
FIRST ROCK SALT, pure white,	2 ft.
Shale and "slate," bluish, with vertical and other seams of salt, from one to three inches thick,	26 ft.
ROCK SALT,	4 ft.
Shales, with Salt,	11 ft
ROCK SALT,	7 ft.
Shale,	3 ft.
ROCK SALT,	3 ft.
Salt and shale, alternate thin seams,	62 ft.
ROCK SALT,	11 ft.
Shale,	1 ft., 2 in.
ROCK SALT,	5 ft.
Shales and limestone,	8 ft.
ROCK SALT, bottom of it not reached,	5 ft.
	820 ft.

The shaft makes clear a division that the borings with a churn drill, left in doubt, viz: That there are gray beds below the red beds. The salt is at the bottom of the gray beds. The Quaternary and some Tertiary deposits hide the outcrop of the red beds to the east to a great extent, but in several places in Sumner county, the lowest of the red beds are seen resting on gray beds, which at one time the writer took to be Permo-Carboniferous. At Wellington, however, near the east margin of these gray beds, the salt is found in thinner veins near the bottom and this with the total absence of fossils, leads me to call the gray beds, at least temporarily the *Saliferous horizon*, and class them with the red-beds as Triassic. I have previously stated my opinion that the Saliferous horizon is continuous without break, upward from the Permo-Carboniferous strata, which are well developed further east. The evidence of



GREAT SPIRIT SPRING IN MITCHELL CO., KANSAS.



this will be discussed fully at some future time. One fact in this connection may however be noted here. It is, that near the top of the Permo-Carboniferous, there is a massive deposit of gypsum of great extent. This is not far *below* the salt deposits. Near the top of the red-beds, about a thousand feet *above* the salt, in several counties sonthwest of Kingman, there is another extensive deposit of massive saccharodial gypsum. Still further to the west and southwest are the *Salt plains* of the Cimarron and the Meade county salt pool, which seems to indicate another salt horizon in the same relation to the gypsum as the rock salt beds are to the gypsum at the top of the Permo-Carboniferous. The Meade county pool was formed by a sinking of the prairie in 1878, and though it has somewhat silted up since then, this year the southern side has sunk four or five feet more. The photograph from which the plate was made, was taken in the spring of 1888.

The relation of certain salt marshes in northern Kansas and the salt pool—a natural artesian flow—called the Great Spirit spring in the same region, to the other salt horizons, has not yet been clearly made out because opportunity for investigation has not been had, but it is believed that this relation will easily be determined.

Returning to the Kingman mine, there are one or two points of mineralogical interest. There are in the "red beds," seams of gypsum in the form of satin spar, much of it pure white, some of it stained with the prevailing ruddy hue. In the gray beds there are vertical seams of the same form hardened to alabaster and taking a fine polish, but mostly stained red. Between the beds of rock salt, the gray shales have seams of salt, vertical, diagonal and horizontal, some purely white, others stained red, and some of the form of satin spar, the fibers as usual, at right angles to the direction of the seam. It is suggested that this halite is a pseudomorph of fibrous selenite.

[Note—The illustrations used in this paper are by the kind permission of Hon. M. Mohler, secretary of the Kansas State Board of Agriculture.]

CLASSIFICATION AND ORIGIN OF THE CHIEF GEOGRAPHIC FEATURES OF THE TEXAS REGION.

By ROBT. T. HILL, Austin, Texas.

II.

THE VALLEYS OF EROSION.*

The drainage accompanying the elevation of every plain is a record of its decay and destruction. In a previous paper I have classified the drainage systems of the Texas region into four great classes: (1). Those rivers which rise in the Rocky mountains and traverse the whole system of topographic plains, such as the Arkansas and the Rio Grande, with their principle tributaries, the Canadian and Pecos. (2). Those which rise in the eastern border of the Staked plain and which are gradually destroying it by headwater erosion, including the Red, Brazos and Colorado. (3). Those which rise in the natural springs along the great Balcones fracture, and (4) the tidal and incipient drainage of the coastal prairies and Eo-Lignitic region. *The drainage topography of each river system is different in each plain*, and resulting therefrom is a diversity of basins and valleys, only the chief features of which will be mentioned, leaving to others and future investition the more detailed interpretation.

In addition to the valleys clearly attributable to the present drainage, there are more ancient and extensive grooves, which are radically different, and in some cases probably antecedent to the present streams, and which can not be interpreted by them. The most conspicuous of these ancient features are: (1). The great valley of the Canadian through the Staked plain. (2). The trans-Pecos basins. (3). The older valley of Red river. (4). The Plateau gravel depression of southwest Arkansas. (5). The older terraced valleys of the Grand Prairie and coastward regions.

The Older Valley of the Canadian.

The Staked plain is no doubt a remnant of the great plains of eastern Colorado, Kansas and Nebraska, but it has long since been separated therefrom geographically by a great valley of erosion, which for convenience I here termed the Older valley of the Canadian. It is in the topography and structure of this and similar valleys that we must look for the history of the plain.

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*See the illustrative map of Texas in the January number of the GEOLOGIST.

This valley is from twenty to sixty miles in width, and about 800 feet below the level of the plain. It transects its entire width from the 100th to the 105th meridian. Its walls, especially the south one, are very steep and apparently perpendicular when viewed from below, forming a grand and beautiful feature in the landscape. The bottom of the valley is but slightly concave, almost a plain itself, and covered with an extensive detrital formation of calcareous pan, accompanied by siliceous pebbles. much worn and rounded. For this formation I have proposed the name Terra-Blanca, used by the Mexican inhabitants of the valley.

Within this valley and running through it is developed the modern drainage system of the Canadian, a mere pin-scratch in proportion to the larger chasm. This cuts through the Terra-Blanca formation into the Red Beds and its flood-plain has the general aspect of the drainage of the Red Bed region. The Canadian of to-day, with its laterals, is newer and subsequent to the ancient valley. The writer has traversed only two hundred miles of this valley, and then so hastily that he must leave it to others to work out its detailed structure and history. The investigator who will take up the study of this ancient chasm, and ascertain its origin and that of the Terra-Blanca formation which fills it, will find in it the key to the later geologic history of the western United States.

The Older Valley of Red river.

A somewhat analogous valley to that of the Canadian is to be found on the Indian Territory side of Red river between the 98th and 96th meridians, as transected by the Missouri, Kansas and Texas and the Atchison, Topeka and Santa Fe railways. Here the modern Red river flows through an ancient alluvial deposit of from twenty to forty miles in width, filled mostly with the debris of the Red Beds, and far above the altitude of the present stream. Too little is known of this valley to discuss it here, except to say that its direction suggests a continuation with the Canadian valley on the west and the Little Missouri valley on the east. Nearly all of the Grand Prairie north of Red river has been destroyed by this erosion.

THE RIVER TERRACES OF THE BLACK PRAIRIE AND EO-LIGNITIC REGIONS.

All the rivers of the first class occupy wide and deeply terraced basins as they cross the Black Prairie and Eo-Lignitic regions, and in places these extend westward to the eastern edge of the Grand Prairie. These terraces, at Austin,[6] upon the western edge of the Black Prairie, extend two and one-half miles inland from the present flood-plain, and attain an elevation of two hundred and fifty feet. They are especially common in the Eo-Lignitic region where the ancient drainage has nearly destroyed the continuity of the plain. Bones of the mastodon and elephant are found in most of these deposits.

THE LAKE BASINS OF THE TRANS-PECOS MOUNTAIN REGION.

Other important valleys of erosion and sedimentation are the recently drained lake-basins of the Trans-Pecos mountain region. These are extensive flats, as they are locally termed, which occupy nearly all of the intervening space between the peculiar and apparently unsystematic mountain groups west of the Pecos. "Eagle flat" near the junction of the Southern and Texas Pacific railways, is a fair illustration of this struc true Here the lake structure is very apparent, and so well preserved that it is not difficult to imagine that the waters have only been recently drained. In other places in Texas and in Mexico these basins are still occupied by saline lakes. The present valley of the Rio Grande east of Ysleta is cut out through one of these basins. More will be said of these basins later.

MOUNTAINOUS AND DISTURBED REGIONS.

Having classified the plains and valleys of the Texas region let us turn to the mountains or other records of disturbance and elevation. The whole region is included in the apex of an angle between two great and important mountain systems, upon the north and southwest respectively, while within the heart of the state is a little known area which has once been the scene of much disturbance. In addition to these the great fracture of the Balcones, has extended across the state from one great mountain system to the other. In these systems are to be found the history of the limitation and elevation of the plains, and other important bearings upon their origin.

The Ouachita Mountains.

South of the Arkansas and Canadian rivers and north of the Red river, extending from the vicinity of Hot Springs, Arkansas, through Indian Territory to the 100th meridian in Texas, is one of the most important, but least appreciated orographic systems in the United States and especially important to the Texas region, inasmuch as it is the northern limit of most of its peculiar geologic features, and the great barrier which differentiates it in every natural aspect from the Missouri-Kansas country. In a previous paper I have spoken of this as the Ouachita system—a name proposed by Dr. John C. Branner, of the Arkansas survey, who, we expect, will bring out its details as a result of the careful survey now being conducted by him.

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[6] See this journal, May, 1889.

In Arkansas the different parts of this system are known as the Rich, the Poteau, the Black Fork, Round Mountain, etc. West of that state it includes in its trend the groups locally known as the Seven Devils, the Shawnee hills, the Kimishis, the Tishomingo, Potato hills, the Arbuckle and Delaware mountains, the Witchitas, and the Navajoes—the last near the line of the 100th meridian.

This system consists of several kinds of topography. This may be (a) narrow, elevated parallel ridges, with deep intervening valleys, as seen along the old military road from fort Smith to fort Washita, (b) of exceedingly irregular masses, separated from each other as in western Arkansas and eastern Indian Territory, and possessing the most erratic outline and extent, as beautifully shown upon the contour maps of the United States geological survey, or (c) of low knolls or hills, which are so inconspicuous as to be no longer worthy of the name of mountains, except from a structural standpoint. The last are characteristic of the central portion of the system, in the Chickasaw Nation, Indian Territory, near Stringtown and Tishomingo where they are known as Potato hills. Again, the apparent continuity of the whole system is broken for many miles by intervening plains, as between the Arbuckle and Witchita mountains. The former eastward continuity of this system has beeen destroyed by the erosion of the Mississippi embayment—the western end is buried beneath later sedimentation of the Staked Plain. The eastern and western extremes of the system present the most conspicuous elevations. In the Arkansas portion the tops of the ridges stand as high as two thousand feet above the adjacent low plain of the Red river drainage, and can be seen from a distance of sixty miles or more, provided one can secure a view unbroken by the dense timber of the region. The western end, as seen in the Witchita mountains of the Comanche and Kiowa reservations, also consists of bold and conspicuous elevations, resembling somewhat the topography of the Arkansas end.

According to captain Randolph B. Marcy, who describes the Witchitas in his report upon the "Exploration of Red river," they are made up of three distinct ranges running from northeast to southwest. "They appear to be in groups, or in clusters of detached peaks, of a conical form, indicating a volcanic (igneous?) origin, with smooth, level glades intervening; and rising, as they do, perfectly isolated from all surrounding eminences upon the plateau of the great prairies, their rugged and precipitous granite sides almost denuded of vegetation, they present a very peculiar and imposing feature in the topographical aspect of the country." "The numerous peaks rise from eight hundred to nine hundred feet above the river. Mount Webster, one of the most conspicuous, was found to be 783 feet above the plain, by the barometer. Twelve of these elevations were found to be composed of granite, which in many places is undergoing rapid disintegration."[1] Of one of these Marcy says:

"We are at this place directly at the base of one of the most lofty and rugged mountains of the range. Its bare and naked sides are almost destitute of anything in the shape of a tree or plant, and it is only here or there that a small patch of green can be discerned. Huge masses of flesh-colored granite, standing out in jagged crags from the lofty acclivities everywhere present themselves to the eye, and the scenery is most picturesque, grand and imposing.[2]"

The principal sedimentary material composing the Ouachita mountains are shales, sandstones and firm limestones of the Coal Measures of the Carboniferous period. In Arkansas the sandstones have been intensely hardened into a kind of quartzyte and are known as "mountain rock." At Limestone gap and other places in central Indian Territory, the blue limestones predominate. Accompanying these greatly disturbed and metamorphosed sedimentary rocks are many outcrops of both plutonic and eruptive material, such as the peridotytes and granites of Arkansas, the granite bosses of Tishomingo and the red granites, basalts, porphyrytes and eruptives of the Witchitas. Concerning the latter no more is now known than was expressed as follows by Dr. Edward Hitchcock some years ago:

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[1] Dr. Edward Hitchcock in Marcy's exploration of Red river, p. 147.

[2] Ibid, p. 68.

"The rocks of these mountains are traversed by veins of greenstone and quartz. The latter is often porous and colored by the oxide of iron. The greenstone is the most recent of the unstratified rocks among my specimens, save a single vesicular mass, broken probably from a boulder, which has all the external marks of lava. It looks more like recent lava than any specimens I have ever met among greenstones or basalt. It was collected west of the great gypsum deposit, though in a region abounding in sandstone, and near the bluffs that form the border of the Llano Estacado. Dr. Shumard found in the bed of Red river near the same place, what he calls greenstone porphyry and trachyte. The specimen to which I have referred is rather augitic than trachytic. He says also that he found there a 'black scoria and other specimens of volcanic rock.' Again, on approaching the Witchita mountains on the return trip he describes one as a truncated cone with a basin-shaped depression in the summit; of which he seems to have judged by looking at the mountain from a distance. But taking all the facts into account I can not but feel that there is reason to presume that volcanic agency has been active in that region more recently than the trap dykes."[3]

The structure of the system has not been studied as a whole. For the most part, however, it consists of almost vertical folds of the composing stratified rocks, as shown in the section along the Arkansas-Choctaw line,[4] at and in the beautiful water gap of the Washita, along the line of the Santa Fe railroad, in the Chickasaw Nation. Accompanying these are dykes and veins of igneous material as well as great masses of granite. The general trend of these folds and ridges, as seen at the extremes both in Arkansas and in Indian Territory, is about 10° south of west—a fact which has considerable bearing upon the subsequent topographic development of the region.

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[3] Dr. Edward Hitchcock, pp. 146-147 of Marcy's report on Red river.

[4] See Am. Jour. Sci. April, 1889.

The importance of this mountain system and its relation to the climate, the structure and the cultural conditions of the Southwest have never been defined. It is the presence of this elevated barrier in Arkansas that protects the sub-tropical Louisiana region from the cold "northers" which blow through the central gaps and lowlands of equal latitude in Texas making that state so much colder. It is this mountain barrier that condenses the moisture from the gulf of Mexico and precipitates in the southwestern Arkansas region fifty inches of rainfall annually, while along its almost destroyed central course the country is nearly arid. To these mountains are attributable the wildness of the country of western Arkansas and central Indian Territory, which are perhaps still the most impenetrable fastnesses of our country. The present bearing of these mountains upon the Texas region, however, is inconspicuous in comparison with the grand part they have played in the past; for from all the evidence it is apparent that the present elevations of this system are merely remnants of an ancient and once magnificent system between the Appalachian and Rocky mountain systems, as the Uintas now connect the Rockies and the Wasatch. They were elevated after the close of the Carboniferous, as shown in the almost vertical fold of the rocks of that period which compose by far their greater portion. It is also probable that this elevation was prior to the deposition of that little studied series of early Mesozoic rocks spoken of in this paper as the Red beds, for which Dr. Hitchcock long since applied the name of the "Red Clay formation." More evidence is needed to elucidate this point however. That the greater portion of the system remained dry land during the Lower Cretaceous, the Upper Cretaceous, the Tertiary and the Quaternary epochs of subsidence is also evident from the absolute non-conformity with which the sediments of those periods are laid down against them. There were gaps, however, even in Lower Cretaceous time, when these earlier seas washed through these mountains and deposited their sediments as far north as Kansas, sediments that underlie most of the great plains of Texas (except the Staked Plains and the Coast Prairies) such as the Grand, the Black the Eo-Lignitic and the Plateau Gravel respectively—and prevented their extent northward into Kansas, thereby differentiating the Texas region from all the rest of the United States.

The main portion of the system, however, has remained dry land throughout the incalculable period of time which has elapsed since its uplift, in common, we will assume, with the Appalachian uplift, gradually yielding to the wear and tear of atmospheric erosion, including the numerous climatic changes. When we consider the enormous denuding effect of these agencies acting through even short periods of time, it is justly a subject of wonder that any portion of theOuachita system should have survived it. The atmosphere, however, has not been the only agent in accomplishing the obliteration of this once conspicuous mountain system, for, as above mentioned, it has been the shore line, during all this time, of numerous oceanic invasions, accompanying the subsidences and elevations, as recorded in the sediments deposited against it. The evidence of the excessive destruction of the southern front of the system from shore action is plainly recorded. In a previous paper[5] I have shown beneath the Tertiary or Quaternary overlap near the Arkansas-Choctaw line, the record of many miles of this planing away of the mountain folds by shore action, and if I may be excused for advancing a hypothesis, I will state that it is my belief, founded upon reasonable evidence, that in the Eo-Lignitic epoch, the whole eastward continuation of the system was destroyed by combined atmospheric and shore action, producing the topographic area now known to geologists as the Mississippi embayment.

The chief agent, however, in destroying the topographic integrity of the original Ouachita system has been neither erosion nor shore action, but subsidence, for a large and important southwestern extension of the system, occupying the central portion of Texas was virtually buried beneath the profound subsidences of early Mesozoic time, and especially during that important epoch of the Comanche series which has been so little appreciated in American geology. Evidence of this burial is afforded in the Central Denuded region of Texas, where the imbedding strata have been sufficiently destroyed to afford some testimony upon the subject as will be shown later.

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[5] See American Journal of Science, April, 1887.

The mountains of the Trans-Pecos country.

Entirely distinct in every characteristic of age and structure are the mountains constituting the southern margin of the Texas region. These can be briefly defined as occupying the country west of the Pecos in Texas and New Mexico, and their continuation into the republic of Mexico, their northern margin approximately coinciding with the Rio Grande, east of the mouth of the Pecos. No attempt has been made to study and classify them, and to-day almost nothing is published concerning the details of their structure, history and relations to each other. So far as known they consist of numerous peaks, mesas and ridges—isolated or in groups—to the individuals of which over thirty distinct names have been applied in Texas alone. Some of these, as has been recorded, may possess granitic axes. Others are highly disturbed sediments of all ages from the Silurian to Post-Laramie, sometimes capped with lava, as seen in the Eagle mountains. Concerning their minute stratigraphy little has been published of a reliable nature. In crossing the region several times, however, I have been able to see that the whole system has been elevated through the characteristic topography and rocks of the Grand and Black Prairie regions, i. e., the lower and upper Cretaceous respectively. This is readily seen by transecting them from east to west, along the line of the Southern Pacific railway. The first intimation of the mountain disturbance west of the Pecos is the increased dip in the eastward inclination of the rocks of all the Black and Grand Prairie region or the upper and lower Cretaceous systems respectively. This eastward dip gradually increases as we go westward, and mountain peaks soon succeed the rugged edges of the plains, and the eastwardly dipping Cretaceous limestones are seen to rest on the almost vertical rocks of presumably paleozoic schists. Continuing westward to the apparent heart of the region, near Eagle Springs, the Cretaceous rocks become highly metamorphosed, and are crumpled in various directions, and overlain by great eruptive sheets. Still continuing westward in the vicinity of El Paso there is an appearance of faulting on an extensive scale, as seen along the south side of the Rio Grande for a hundred miles below that city. The main questions of mountain structure and relation, however, as before stated, still remain unsolved. Between the individuals or groups that compose this unclassified system, are the extensive flats, composed of the lacustral sediments of the post-Tertiary waters that once covered the region. The importance of these flats or basins has usually been overlooked. They probably constitute two-thirds of the whole region and in the study of their structure and origin will be found the key to the late history of the region. In fact it may ultimately be shown that the mountains of the trans-Pecos region are simply concealed beneath the lacustral sediments of the lakes which once converted them into islands and shore lines.

Little has been added to the knowledge of these mountains since the report of the United States and Mexican Boundary survey, in which many fine illustrations and descriptions of their topography are given and wherein it is said that "the succession of basins form a prominent feature in the geography of North America, extending two-thirds its length and quite one-third its breadth. They belong to what has been appropriately designated as the Basin system of North America.[1]"

The chief bearing of these mountains upon the geography of the region, however, is that they were elevated through the great plains of the state, with the exception of the coast prairie and perhaps the Eo-Lignitic region, and are in a large part composed of the stratigraphic remains thereof, thus forming a natural limit to the whole of the Texas region under discussion.

The possibilities which may result from future investigation in the mountain structure of the region are most inviting, as well as the temptation to yield to speculation concerning them.

Within the triangle formed by the projected axes of the Ouachita, and the trans-Pecos mountain systems and the Balcones fault, however, will be found the most important light that can be thrown upon the stratigraphic, orographic and topographic history of our southwestern country. Where the axes of the trans-Pecos and Ouachita systems meet in northwestern New Mexico is the great Rocky mountain elevation, which brought all of the Texas plains to their present altitudes, and produced the present coastward inclination.

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[1] Report on the U. S. and Mexican Boundary survey, vol. I, p. 46.

The Balcones fracture, extending from system to system at right angles to this resultant of general elevation, with its ancient volcanoes and faulting, is pregnant with suggestions of a long continued line of structural weakness, subtending ancient coastal plains, while the little known disturbances of the granite region, are sufficiently near it to suggest an ancestry and lineage of sedimentary disturbance along this line, more complete in its record than any other fracture in our land.

Having now outlined the great plains and mountains of the Texas region, Part III of this paper will be devoted to a study of its topographic history as interpreted in its ancient shore lines, subsidences and river systems.

EPITOME OF THE CHIEF TOPOGRAPHIC AREAS OF THE TEXAS REGION.

Explanatory of the accompanying map. See p. 9.

I. PLAINS AND VALLEYS IN PLAINS.	ALTITUDE.	CHARACTER AND AGE OF SUBSTRUCTURE.	AGE OF TOPOGRAPHY.
A. *Valleys of erosion.*			
1. Terraces of the rivers of east Texas.	200 (above present flood-plains.)	Transported up stream debris.	Post-Tertiary deposits, the history unsolved.
2. Trans-Pecos Lake Basins.	2000.	Lacustral loam and debris.	Latest Quaternary and recent; little studied. Great Basin epoch.
3. Great Valley of the Canadian.	2000—3000.	Alluvial calcareous debris or "Terra Blanca," deposited upon the Red Beds.	Early Quaternary. Later than Staked Plains. Newer than present drainage. Grand canon epoch, or "Middle Tertiary" of Dutton.
4. River Systems. (a) Rivers of the RioGrande-Arkansas System.			Antecedent to Staked Plains formation, or Pre-Tertiary.
(b) Rivers of the Red, Brazos and Colorado System.			Subsequent to Staked Plains and Grand Plateau epochs. Early Quaternary??
(c) Rivers of the Nueces, San Antonio and Guadalupe System.			Subsequent to Balcones epoch.
(d) Rivers of the Coastal and Mississippi-lateral System.			Post-Tertiary and recent.

5. Depressions produced by Denuded Anticlinals. The Central Denuded Region.	750—2000.	Jointed, folded and other disturbed, sandstones, clays, limestones, granites, etc., of Pre-Cretaceous age.	Ancient disturbed areas, probably part of the Ouachita disturbance, which have alternately served as the continental divide between the interior basins and the Atlantic. It was buried in Lower Cretaceous times, but was land in the Jura-Trias and Laramie-Eocene epochs. Since the greater elevation of the western region, It has rapidly succumbed to erosion, and is now a depression in the centre of the state.
(a) The Upper Cross Timbers.	1000.	The basal sands of the Comanche Series known as Pock Sands.	
(b) The Older Rock -(Paleozoic) Areas.			
b′ The Palo Pinto or Coal Measure Area.	1000—2000.	Sandstones, limestones, clays and coals of upper Carboniferous	
b″ The San Saba, or Granite Area.	1000—2000.	Older limestones, schists, etc., with above and later granites.	
(c) The Red Beds.			
c′ The Abilene country.	2000.	Dark red marly clays and sandstones.	
c″ The Gypsum country.	2000.	Light red marly clays and sandstones with much gypsum.	
B. *Plains.*			
1. The Coast Prairie Region.	0—200.	Shallow marine and littoral sediments of Port Hudson epoch of Hilgard and Loughridge.	Latest Quaternary.
2. The Eo-Lignitic, or Sandy Region.	200—500.	Marine littoral clays, sands and lignites, of Eocene and Miocene("Grand Gulf") epochs.	Early Quaternary. Plateau Gravel epoch,
3. The Black Prairie Region.	500—750.	Marine sediments of Upper Cretaceous (Meek and Hayden) section.	Intimately connected with the above. its western margin probably being older, or the first portion of the plain made during the Plateau Gravel epoch.
Subdivisions.			
(a) Main Black Prairie.		Infra-littoral clays, (Ponderosa marls, Pierre etage.)	
(b) Chalky Division.		Infra-littoral chalks. (Niobrara etage). Austin chalks.	
(c) Minor Black Prairie Division.		Infra-littoral clay. Benton etage. Eagle Ford shales.	
(d) Lower Cross Timber Division.		Littoral sands. Dakota etage.	
4. The Grand Prairie Region.	750—2000.	Marine sediment, chalk, clays, oolite, yellow marls and basal sands of Comanche series.	Probable remnant of a plain that existed from early Tertiary time to the present. Lignitic epoch.
5 The Staked Plains Region.	2000—4000.	Surface, lacustral sediments of Tertiary origin. Foundation, marine sediments of Mesozoic epochs.	Probably a great lake region in the Miocene or the Pliocene, antecedent to IAS, and elevated to its present altitude in Post-Tertiary time, probably synchronous with Zuni Plateau.

II. MOUNTAINS, FRACTURES AND ERUPTIVE AREAS.			
1. The Ouachita mountains.	3000.	Disturbed and Paleozoic sediments and igneous material. Granites and eruptive.	Elevated very soon after the close of the Paleozoic. Eruptive and slight movements at various epochs since. Appalachian epoch.
2. The Rocky Trans-Pecos mountains.	2000—9000.	Pre-Tertiary sediments. Eruptives, etc.	Greatest elevation and disturbances in post-Upper-Cretaceous time. Tertiary and later.
3. The Shumard Knobs and Balcones Fracture.		Lower Cretaceous and later sediments. Basaltic, and other eruptives.	Post-Tertiary, probably coincident with the latest disturbances in the Rocky mountain region. Balcones epoch.

[TO BE CONTINUED.]

ON THE SILURIAN SYSTEM OF ROCKS.

By RODERICK IMPEY MURCHISON, F.R.S.,

Vice-President of the Geological and Royal Geographical Societies,* &c., &c.

Geologists have long felt that the older sedimentary deposits required a systematic examination. I have devoted the last five years to the study of this class of rocks, hoping thereby to fill up certain pages which were wanting in the chronology of the science. (See Lond. and Edinb. Phil. Mag. 1832 to 1835, in the Proc. of the Geol. Soc.) A table published last year was the first attempt to convey to the geological student a correct view of the thickness, variety of strata, and fossil organic contents of a vast system, which, though arranged by nature in the most lucid order of succession, had not previously been pointed out. These rocks rising from beneath the old red sandstone in Herefordshire, Shropshire, Radnorshire, Brecknockshire, Monmouthshire, and Caermarthenshire, and each distinguished by separate and *peculiar organic remains*, were respectively named after those localities where each of them could be best studied, and their places in the series most clearly established. I have no change to announce in the order detailed in that table [see Lond. and Edinb. Phil. Mag., vol. IV, p. 370], but I wish to simplify it by the abandonment of double names, as applied to any one formation, and by the adoption of the names of those places only where the respective rocky masses lie in juxtaposition.

The names finally adopted and which will be incorporated in a work now in preparation on this subject, are,

1. *Ludlow rocks*, divided into upper and lower Ludlow rocks, with a central zone of limestone: in this formation no change of name is proposed.

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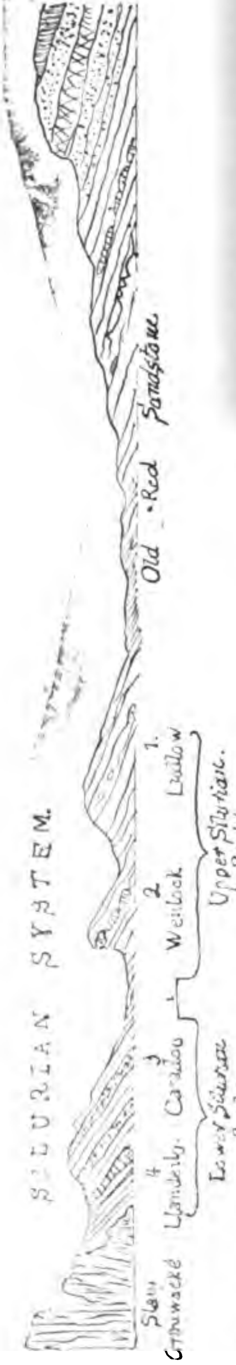
*From the London and Edinberg Philosophical Magazine and Journal of Science, 3rd series, July 1835, page 46. [This is the original announcement and description of the Silurian system.—ED.

2. *Wenlock limestone* and shale [equivalent, Dudley].

3. *Caradoc sandstones.* This name, supplying the place of the Horderley and May Hill rocks, has been derived from the striking and well known ridge of Caer Caradoc, on the eastern flanks of which, and lying between it and the Wenlock Edge, are exhibited those peculiar strata which are the equivalents of the shelly sandstones of Tortworth.

4. *Llandeilo flags* [preferred to "Builth and Llandeilo"]. When this table is reprinted, there will be found many additions to the organic remains, some identifications of British with foreign, and numerous corrections.

Notwithstanding the adoption of these names, there was still required a comprehensive term by which the whole group could be designated, and at once distinguished from the *old red sandstone* above, and the *slaty rocks* below. Without such a collective name for the group I found it impracticable to proceed with the work which I had engaged to complete, it being essential to the clear exposition of the subject, no longer to speak of these deposits as "transition rocks" or "fossiliferous grauwacke." The term "transition" might indeed, have been retained, if for no other reason than to impress upon foreign geologists, [the Germans particularly] how vast a difference exists between the geological horizon of the mountain or *carboniferous* limestone and that of the limestones of Dudley and Wenlock, which are not only separated by many thousand feet of strata from the limestone of the carboniferous system, but further, contain an entirely distinct class of organic remains. It was, however, utterly hopeless to use the word "transition" in any definite sense as applied to these lower deposits, seeing the extent to which it had been abused. By some it was confined to those older rocks in which the earliest traces of organic remains were supposed to be observed, whilst others had more recently so expanded the meaning as to comprehend in it the whole of the carboniferous series! Thus at a period when, from the rapid advances of the science, it had become indispensable to define the boundaries of groups naturally distinct from each other, dissimilar things were still confounded under one common name! and hence every geologist with whom I am acquainted had been for some time agreed upon the expediency of obliterating the term. The name "transition" is in truth, not applicable to any one class of stratified deposits in preference to another. Thus, for example, within the area of a map now preparing for publication and embracing parts of ten counties only, I shall be able to show transitions into every formation, beginning with the inferior oölite and terminating in descending order with the Llandeilo flags, many thousand feet below the old red sandstone; whilst the latter overlie other fossiliferous masses, the relative ages of which yet remain to be worked out! In various memoirs read before the Geological Society I have described these rocks as "fossiliferous grauwacké," but this term is in reality a misnomer, as the group contains few if any



SILURIAN SYSTEM.

strata of thet rue grauwacké of German mineralogists. But whilst this system contains no such beds, it is underlaid and sometimes indiscordant stratificatton, by a vast series of slaty rocks, in which much genuine grauwacké *is* exhibited. It is therefore manifest that if used at all in geological nomenclature, the term "grauwacké" must be ejected as inapplicable to the first great system below the old red sandstone, and restricted to rocks which were *now* proved to be of much higher antiquity. My friend Professor Sedgwick will doubtless soon dispel the obscurity which hangs over these grauwacké rocks, with which his labors in Wales and Cumberland have so well enabled him to grapple.

To return, however, to the system under review, I was urged by leading geologists both at home and abroad to propound an entirely new name for it. In consonence, therefore, with those views which have rendered the names used by English geologists so current throughout the world, I venture to suggest, that as the great mass of rocks in question, trending from southwest to northeast, traverses the kingdom of our ancestors the Silures, the term "Silurian system" should be adopted as expressive of the deposits which lie between the old red sandstone and the slaty rocks of Wales, including, as above detailed, the Ludlow, Wenlock, Caradoc aud Llandeilo formations. One of the largest of these formations, to which, indeed, the Llandeilo flags are frequently subordinate, has been named after the bold and picturesque ridge of Caer *Caradoc* in Shropshire.

I further propose that the system be subdivided into "Upper" and "Lower Silurian rocks," the former embracing the deposits of "Ludlow" and "Wenlock," the latter those of "Caradoc" and "Llandeilo." By this arrangement the observer will not be embarrassed when he finds that certain typical strata have disappeared. Thus, for instance, when the zones of limestone thin out, by which the formation of Ludlow and Wenlock are subdivided, it is no longer practicable to mark lines of separation between them. Under such circumstances the united mass will simply be described as "*Upper Siluran rocks,*' whilst wherever similar causes prevent the separation of the "Caradoc sandstones" from the "Llandeilo flags," the two will be termed *"Lower Silurian rocks."*

A wood cut is annexed, explanatory of the manner in which these deposits are connected with the old red sandstone above them, with each other, and with the slaty grauwacké rocks beneath them. Although the lower Silurian rocks are frequently unconformable to the schistose grauwacké, as represented in the wood-cut, there are situations in which a passage from one to the other may be detected.

Having alluded to a work which is in preparation upon the geology of the country of the Silures, and of several of the surrounding counties, I may take this opportunity of acquainting those friends who have fostered the undertaking, that the author is unceasingly occupied in promoting its completion. Geologists are not, I am sure, among those who feel surprise at the delay; for they well know that so large an area of country, and one so little previously examined, could not have been adequately described without several years of hard labor. In the mean time I may state that a man is now constructing, being a precise reduction of the Ordnance Maps, extending over the greater part of ten counties, all of which have been geologically colored in the field; together with about twenty plates of engravings of fossils, many of which are of new species, and a vast number of colored sections, vignettes, &c., all of which will, I trust, be completed so as to enable me to lay the work before the public in a few months.

P. S. Authorities differ in opinion concerning the exact geographical boundaries of the kingdom of the Silures, &c., &c., &c.

ILLUSTRATION OF THE "LEVEL OF NO STRAIN" IN THE CRUST OF THE EARTH.

E. W. Claypole, Akron, O.

Investigations regarding the condition of the interior of the Earth have been recently stimulated and directed in no slight degree by the publication of various papers by Messrs. Read, Davison, Darwin and Fisher. These workers on the physico-mathematical side of the subject have introduced to the notice of geologists a condition previously overlooked, but nevertheless of very great importance. As a deduction from the physical laws that govern the constitution and condition of the deeper parts of the globe, lying beyond the reach of direct observation, this inference commands attention. Whether it finally proves to be exactly as its investigators claim or not, the investigation itself will be of very great advantage to the science by clearing and sharpening our conceptions upon a very difficult topic.

A short summary of the progress that has been made in this direction was contributed by the writer to the pages of THE AMERICAN GEOLOGIST in June and July, 1888. The present paper does not record any new advance, but is merely intended to present the matter in a slightly different aspect, and without entering into much detail, to show to a non-mathematical reader the position taken by the mathematicians. Only the two principal data will therefore here be introduced. These are (1) the amount of contraction suffered by each cooling shell of the Earth, and (2) the diminution of the space occupied by each in descending to a lower level. The whole problem is merely the investigation of the relation which these bear to each other.

The Earth being a cooling globe, every layer of it from the center outward is gradually falling in temperature. But evidently at the surface and at the center the chilling process is reduced almost to zero, because in the one case the surface is already cold and in the other the center is so deeply covered that the escape of heat is inappreciable. Physicists tell us that at so slight a depth as four hundred miles the cooling is infinitesimally small, and may be neglected. All the investigations, therefore, may be confined to a superficial shell four hundred miles in thickness. Below this is a nucleus or core practically unchanging in temperature and size from century to century.

Between these two zero limits is contained at present the cooling shell of the Earth. In this layer there must obviously be a level where the cooling reaches maximum. A moment's thought will render this clear to everyone. It is a consequence of the elementary laws of heat, and is as true of an iron cannon ball as of a planet. This layer of greatest cooling is placed by the physicists, at the present time, at between seventy and eighty miles deep, or at about one-fifth of the thickness of the cooling shell.

Obviously this layer of maximum cooling must nearly, if not exactly, coincide with that of greatest contraction. Every cooling shell shrinks in three dimensions. It becomes shorter in circumference along two great circles at right angles to each other and it becomes thinner. The shell of greatest cooling will therefore show most diminution in thickness, and at the same time will tend to crack and leave open spaces in consequence of its shortening along the two great circles.

But under so great a pressure as that which must exist at the depth indicated the formation of open spaces is impossible. The material there existing, whatever its nature, must be plastic under a weight so enormous and at a temperature so high. Every space must be filled up almost before it is opened. The contraction in three dimensions is consequently reduced to shrinkage in one—the vertical—which becomes three times as great as it would otherwise be, the horizontal shrinkage in the other two directions entirely vanishing. This is the region of "stretching" of Mr. Davidson which might perhaps with greater propriety be called the region of "squeezing" when we consider the manner in which the forces act.

In the annexed figure (1) the outer curve is intended to represent the amount of contraction suffered by every thin shell of this crust between a depth of 400 miles and the surface. Beginning at the former with a slight curvature and very close to the radius to indicate small amount and slight increase, it gradually diverges as the cooling of the shells and consequently their contraction increases until it reaches its maximum at the depth as already mentioned of 70 or 80 miles. Returning from this point the curve rapidly approaches the axis as the cooling and contraction again diminish until at the surface where both become zero the two lines meet

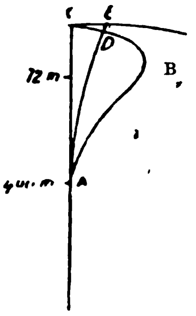


Fig. 1.

ABC—curve of shell contraction.
ADE—curve of loss of space by descent.
B—level of greatest cooling.
D—level of no strain.
A—depth of 400 miles.

This curve then represents to the eye the contraction of every shell of the sphere between the limits named and indicates a slow increase of the contraction in the lower layers, becoming more rapid as the maximum is approached and falling with greater rapidity, after this point is passed, to zero at the surface. Such is, without claiming too great accuracy, the actual condition of the region in question.

Passing now to the second datum of the problem it is easy to see that owing to the contraction of every shell there must ensue a regular and increasing descent of all except the lowest.

Indeed the upper surface of the lowest descends as shown above, three times as far as the shrinkage in any one direction requires. But the upper surface of the second shell must sink by about the same amount in consequence of its own contraction and must also settle down on the sunken surface of the first. Were their contractions equal, which is not the case, the settlement of the second shell would be double that of the first but as the cooling increases upward its actual descent is rather more than this.

Evidently this settlement steadily and incessantly increases upward, its sum rising faster and faster until the layer of maximum cooling is reached and then more and more slowly to the surface. The increase does not in this case as in the former pass into a decrease at any point. Consequently its total amount is greatest at the surface though its increase is very small indeed through the superficial layers. That is to say, in other words, that the fall of each shell in consequence of the contraction of those beneath it commences practically at the depth of 400 miles and becomes greater up to the superficial shell which falls most, the maximum increase being at or near the shell of greatest cooling.

It is almost needless to point out that in consequence of the spherical form the fall of the different shells is accompanied by a narrowing of the space which they must occupy. The nearer to the centre they fall the narrower this space will be. did every shell descend equally the change of space might be represented by a straight line diverging from the axis to the surface, every step of fall being represented by an equal diminution of space. But as shown above their descent is not equal. Consequently the successive positions must be represented by a curve, similar in general form to that in fig. 1. Starting with the other from zero, at a depth of 400 miles, it diverges from the axis more rapidly as it rises until the level of maximum cooling is passed, when the previous rate of increase as shown above, becomes less and less as the surface is neared.

Investigation shows that in the deeper part of that portion of the sphere with which we are now concerned the shrinkage from cooling exceeds the loss of space due to descent. The curve representing the latter will therefore lie nearer the axis than the other.

Both diverge upward until they reach the shell of maximum cooling. But above this level the former returns toward the axis as contraction diminishes while the latter continues to diverge to the surface. It follows therefore of necessity that at some point these curves must intersect each other. This means that at the point where this intersection occurs the values which they represent are equal, or that the contraction in consequence of the cooling of the shell occupying that level exactly equals the loss of space to which it is compelled to submit on account of its descent to a position nearer to the centre of the sphere.

This is "the level of no strain" of the authors named at the beginning of this paper. By this term Messrs. Read and Davison, to whom the conception is due, imply that the layer in the Earth's crust occupying this position is neither squeezed out to fill nascent empty spaces as in the lower part of the 400-mile shell, nor crushed by compression owing to the descent of layers already cool and therefore incapable of much further contraction to a level in the sphere too narrow to receive them without folding or crushing. It is a peaceful zone in a crust constantly troubled, a resting layer in an ever restless mass.

In the two papers already alluded to published in this magazine in June and July, 1888, I pointed out sundry geological reasons for suspecting that the "level of no strain" had been set too high by its discoverers and investigators. These need not be repeated here but it may not be uninteresting in conclusion to point out a few of the changes through which this zone has passed since the consolidation of the Earth took place. As the authors have remarked it has descended with time to deeper and deeper positions. For example at the moment of consolidation no such layer existed. The temperature increased from the surface down perhaps to the centre though not at a constant rate. The superficial shell was that of greatest cooling and contraction. The two curves described in this paper were then as shown in fig. 2 and both reached zero at a small depth. But after the consolidation had taken place and the superficial layer had grown cooler but still was cooling

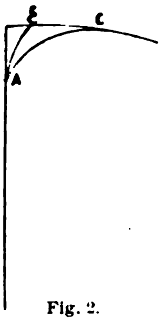


Fig. 2.

somewhat rapidly these two curves took the arrangement shown in fig. 3. The zone of greatest cooling is now below the surface but that surface is not cool enough to allow the curve of contraction to return to the axis. Consequently there was then no "layer of no strain." But at later date when the surface had grown so cool as to cease to give off any perceptible degree of heat the state of things represented in fig. 4 ensued where the curve of contraction returns to the axis or so nearly to it that intersection takes place and the "layer of no strain" appears.

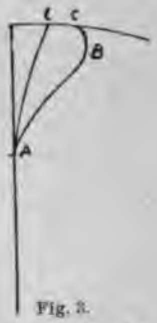


Fig. 3.

From that time to the present this layer has descended lower and lower accompanying at a certain distance the level of greatest contraction and will continue to sink deeper and deeper until the cooling of the sphere is complete.

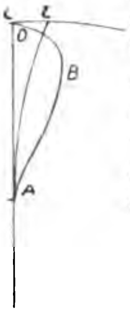


Fig. 4.

THE ORIGIN OF THE PRESENT OUTLINES OF THE BERMUDAS.

By J. Walter Fewkes, Boston, Mass.

The Bermudas consist of a number of coral islands which exhibit curved and crescentic outlines. The "Main Land," the largest of these islands, presents a marked feature in the partial or complete enclosure of at least three basins of water called sounds, which are irregularly oval in outline and more or less completely surrounded by land. The present islands are for the most part strung along in an extended arc of an oval which skirts the platform upon which they are situated.

Two theories have been suggested to explain the position and contour of these islands, the existence of the sounds and their relation to the platform from which the lands rise. These theories may be known as the "subsidence theory" and the "erosion theory." The latter has also been called, not inappropriately, the "cave theory," for reasons which will, it is hoped, appear as we go on.

The general form of the component members of the Bermuda islands is such that one is immediately reminded, when studying a map of them, of the characteristic ring-shaped coral formations of the Pacific ocean, which are known as atolls. Although the group has been regarded as comparable with a compound atoll, or a large ring-shaped coral island with smaller circular lagoons along its rim, it has at least two marked differences from a typical coral atoll which appear even on a superficial study. These differences are as follows:

1st. While very similar to an atoll in contour the land of Bermuda is much more elevated than that of the coral atolls in the Pacific.

2nd. While ordinary atolls are rarely if ever greatly modified by erosion everyone admits that the Bermudas have had their outlines very much changed by this means.

The submarine platform of the islands is an oval bank along the southeastern edge of which the present land masses extend in a crescentic form. With the exception of the North Rocks, isolated elevated pinnacles on the northern boundary of the platform, all the land is confined to the southern and eastern rim. The inhabited islands enclose a number of open bodies of water, or sounds as they are locally called, which represent the lagoons of the supposed compound atoll.

Historically the first interpretation of the cause of shape of these peculiar lagoons was that their form is due to the gradual subsidence of the platform upon which the islands rest. It was thought that they illustrate in the Atlantic ocean the Darwinian theory of subsidence to account for the ring-shaped islands in the Pacific ocean. This application of the theory has not commended itself to one or two geologists to whom it seems insufficient to account for the form of these islands. The facts which were thought to indicate subsidence and the undoubted evidence of erosion has led still other naturalists to a consolidation of the two theories, or rather the engrafting of one on the other, so that the workings of both are looked upon as indicated in the present contour of the islands. The present outlines of the Bermuda are thus regarded by them as due to subsidence assisted by erosion.[1]

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[1] Darwin stated the difficulties in interpreting the Bermudas as a compound atoll, which have never, in the opinion of the author, been satisfactorily answered. This paper does not discuss the literature of the subject.

The study of the tremendous erosion produced by the water, in a mechanical way or as a solvent, on the soft rock which composes the islands leads to a belief that the outlines of the lagoons or sounds are due to an erosion of the same by inroads of the sea. It would seem to a superficial student of the geology of Bermuda that the erosive power of the sea must have been a great factor in the production of the present form of the Bermudas, but it does not seem wholly necessary to combine with that cause subsidence of the ocean bed. Several advocates of the theory of subsidence as applied to these islands admit that erosion has been instrumental in the formation of the contour of the islands, but still hold that subsidence is also an important cause. To the writer, however, it seems more in accord with evidence that the present outlines of the Bermudas are almost wholly due to erosion and that subsidence of the sea floor is secondary in the formation of the present topography. It would be possible even to go farther and say that erosion is almost the only cause of the present diversified coast line of the islands.

This agent is believed to have led to secondary modifications in the geographical contour of such a kind as to impart to the islands a distant resemblance to a compound atoll, but in so doing has rendered evidence drawn from them as to causes as compared with Pacific island atolls somewhat questionable. The factor of erosion which all admit exists in the Bermudas has modified the outlines, imparting to them contours similar to those of atolls of the Pacific where erosion has not exerted its great influence. Arguments, therefore, drawn from similarity of outline must take cognizance of this fact. The present form of the Bermudas and that of the compound atolls may be similar, but that similarity may or may not be due to the same cause. The fact that there is another cause which is amply sufficient, which is present in one case and absent in the other, lends color to the belief that to say that both are results of the same agent is after the nature of an assumption. Similarity of contour does not necessarily mean similarity of cause for those contours, especially

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[2] Local subsidence due to falling in of undermined land masses may have occurred and even the whole platform may have subsided—a supposition yet to be demonstrated—both of these undoubtedly would affect the form of the island, but the immediate cause is erosion.

when we remember that an active modifying agent has exerted its influence in one case and not in the other.

But the evidences claimed to account for the outlines of the Bermudas do not rest wholly on their resemblance to those of compound atolls. It is held that we have in the Bermudas direct evidences of the subsidence of the base. This evidence, which is mainly derived from sunken Cedar trees and submerged cave stalagmites, will be considered presently.

There seems evidence to lead to the belief that ring-shaped coral islands are not all formed in the same way. Prof. Heilprin strongly insists that the Florida reefs are on areas of elevation to which I have no desire to object, but if one regards the Florida reefs as an area of elevation and an atoll as an indication of subsidence how are we to explain the ring-shaped Marquesas islands? Here certainly we have a ring-shaped coral-island in an area which the last mentioned author regards as one of elevation, but there is a danger in supposing that one ring-shaped coral island is necessarily formed the same as another of the same shape because its outlines are similar. My belief is that the outlines of the Florida reefs are determined by ocean currents independent either of elevation or subsidence. There are illustrations which might be used to support the theory that circular reefs may not always be formed in the same way. I think possibly the Bermudas and the Marquesas are such examples. It is possible that some naturalists have found ring-shaped reefs in areas which they regard areas of elevation, others atolls in areas of subsidence, while still a third where there is no evidence of either elevation or subsidence. The causes which might theoretically lead to the formation of ring-shaped islands are certainly not so meagre that each, possibly all, may be right in regard to the islands which they have studied.

The most important evidences of subsidence in the Bermudas which have been advanced are: 1st. The finding of cedar trunks in upright position in submarine excavations, or deposits of "peat" and redsoil in the same or similar excavations. To which may be added the fact that ships in Great Harbor, one of the sounds, have drawn up with their anchors fragments of cedar trunks and roots. 2nd. The existence, according to Thompson, of submarine stalagmites standing in water in caves below the level of the sea.

The finding of cedar trunks and roots under the sea does not in itself seem the most conclusive evidence of subsidence in these islands, especially when we take into account that we are studying islands where erosive action is wide-spread and enormous. In point of fact one is tempted to ask if the existence of trees or terrestrial organic deposits under the ocean is not exactly what would be expected where the evidences of erosion of the neighboring land are so great. Why can not we suppose that these objects have simply fallen to the submarine floor of sounds by the erosion of the rock above which they formerly grew, or have been transported to this position? Is there anything illogical in supposing that the cedar trees have simply fallen or been carried as debris to their present position, rather than to bring in the theory of subsidence to account for their position.

The evidence furnished, contributed by the half-submerged stalagmites, would seem strong proof to instance in favor of subsidence. I have examined many of the Bermuda caves and have not been able to convince myself that any of them have submerged stalagmites which were formed above the present sea level, and consequently as far as the fact of their existence goes I must rely on the observations of others. While not sure that the individual stalagmite mentioned by the naturalist of the "Challenger Expedition" was formed as stalagmites generally, it may be evident that such is the case when we are to learn more of its position, and amount of submergence. Moreover the fact that a stalagmite is now under water does not necessarily mean that sea water penetrated the cave prior to the time when it was formed, although the porous nature of the rock might seem to indicate that fact. A stalagmite of the general character of one in Joyce's cave may have formed before the floor of the cave was as deeply eroded as at present. If the roof of the cave settles what is to prevent the stalagmite being forced under the water. The observations of evidence of subsidence in the whole platform of the Bermudas adduced by observation is not sufficient to prove the theory. What is most needed is more observations and better interpretation of the supposed facts which have been adduced in its support.

While in the opinion of the author the evidence yet adduced is not sufficient to prove that general subsidence of the Bermuda platform has taken place it is certainly not possible to prove the contrary. I feel that our facts shed no light on either theory. There is reason to believe that the water once stood higher around the island than now, but the evidence of subsidence of the land, although accepted by most of those who have studied these islands, is not wholly conclusive.

The Bermuda islands belong to that group of coral islands in which the most important agent at work is the erosion of the sea. Of great erosion there is evidence which no one can question, and the islands are in the process of destruction not construction.[2]

The amount of erosion which is indicated there is stupendous and such as belittles all our ideas of the erosion of the sea on rock derived from a knowledge of the results of these forces on our own coast. The amount of red soil, which I regard as wholly the product of erosion, is in a measure an index of the amount of denudation which has taken place.

The level floor of Harrington sound has been adduced as a proof that no falling in of the roof of caves has taken place, yet the argument is not wholly conclusive. It would seem as if the erosion and scouring of the fallen fragments by the water would level the floor except at the islands in the sound where vestiges of the former land still remain projecting above the water.

It might be pertinent to ask whence came the islands in Harrington sound? Are they not remnants of elevations once much more lofty than they now are, and have they not an important bearing on the problem we are considering? Their eroded sides tell of the inroads of the sea and their summits indicate considerable aerial denudation. Their very existence seems to show that the floor of the sound is not level, although in themselves they do not deny the theory of subsidence. They are believed to show that the caves which formed about them were limited to their periphery, no more, no less. I would not interpret them as the roof of a fallen cave, but as remnants of the originally solid land which before erosion has reached its present amount formerly filled the space now occupied by water.

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[2] I have already pointed out the difference between these two groups of islands. See Proc. Bost. Soc. Nat. Hist. vol. xxiii, also Standard Natural History.

The forces of undermining and falling in of overhanging cliffs can now be seen in operation, and the sea carries off the detritus as it did when Harrington sound was first formed. One can see to-day in the power of active erosion abundant cause for the excavation of Harrington sound without calling to its help a subsidence of the platform on which the islands rest. It may be said that the narrow entrance is not large enough to serve as a channel of exit, but we may conclude that the amount of water which enters Harrington sound is but a part of that which daily flows into that basin. There are subterranean water courses, notably those near Paynter's vale, through which water passes in great quantities. These are possibly agents of erosion as well as of transportation of matter which has been eroded. It is said that the entrance to Harrington sound at "the Flats" is slowly filling, but it is not impossible that the amount of detritus conveyed through this channel is greatly in excess of that left in the passage.

The "cave theory" of the formation of the present outlines of the Bermudas may be stated as follows:

The modification of the coast line of the islands and the formation of the sounds is due to erosion by rain or by the sea. The sea is the most active agent, undermining the cliffs, forming caves or grottos, the roofs of which fall in from time to time, while the debris is in part carried off in solution or mechanical suspension by tides or currents.

In support of this theory there may be instanced observation of the erosion indicated at the bases of the high abrupt cliffs and the caves found everywhere in the existing islands.

The depth of Harrington sound is adduced as an evidence of subsidence. It is asked if the sea could excavate the floor at a depth of fifty feet below its present level. I am not sure that it can not or that instances of eroded caves in harder rock than coral limestone of an equal depth might be adduced. But even this depth does not disprove erosion or prove subsidence. I am not unwilling to believe that there were depressions in the great Bermuda which were never filled by rock, or sand before it hardened into rock. The nucleus of Harrington sound when erosion began may have been one of those. Indeed my whole conception of the manner of the æolion coral rock forms is that the highest elevations of the old Bermuda were contiguous to the active surface. Depressions at a distance from the beach or even near it may not even have had their floors above the sea, and yet the enlargements of these depressions may have resulted as the "cave theory" demands.

An opinion expressed by one of those who accepts the submergence theory is that nothing remains at present of the old atoll of Bermuda except the position, so greatly modified are the contours. I think he is quite right. There is, it seems to me, no necessity even for the use of the term atoll in connection with these islands except to indicate a circular reef with enclosed lagoons. Why is it not better to restrict the term atoll to islands with a different character.

The original island from which the present fragments were derived possibly had a form like many of the Bahamas in which the atoll structure is next to impossible to discover. As an advocate of the "cave theory" it is thought consistent to suppose the proposition that the island on the Bermuda platform in its formation and original condition had the ring-shaped form.

It can be said that the belief that erosion has been the most important factor in the sculpturing of the contour of the Bermudas, imparting to them their present outlines, does not necessarily commit one to the belief or disbelief in a theory of subsidence of the Bermuda platform. The effects of erosion are amply sufficient to explain what we now see in their contours, and their is no reason to look beyond it for the explanation of the lagoons and the parts of Bermuda between North Rock and the existing islands.

While we see everywhere in the islands the formation of caves and miniature examples of what has been carried on with grand results in the past, it must not be supposed that this erosion had any more of a cataclysmal nature than at present. The slow process of undermining of the soft coral limestone by inroads of the sea, and the formation of grottoes and of subterranean waterways honeycombed the land which formerly occupied the place now filled by the sounds, and little by little the roofs fell in to be transported away by an ever-present carrier—the sea. Every rain from the sky played its part in this destruction until under these denudation agencies the great mass of the island disappeared.

The elevation of the island of which geologists think they find evidences could not make up for the losses from the remorseless sea combining with the rains in leveling the soft rock. I have no new observation to add to those advanced by others to prove the theory of an elevation of the Bermuda platform. There may have been an oscillation, elevation and subsidence, but the main cause of the present outlines of the coast is neither one nor the other, but enormous erosion.

If there were no other forces at work an elevation of the platform of Bermuda fifty feet would profoundly affect the general contours of the islands. It seems equally possible that subsidence, if it happened likewise under the same conditions, would change the outline to a marked extent. But in studying the Bermuda of to-day we are studying the *membra dejecta* of a large island whose form we are obliged to surmise from its fragments. We know that those fragments lie on the periphery of an oval ring, but this is only a hint of the former shape of the island. It may have been a compact island covering the whole platform with its greatest elevation where the existing islands now are, yet it does not seem impossible that the original Bermuda was a ring-shaped island. With pronounced evidences, according to geologists, of elevation and of great erosion, the evidence of subsidence are more or less marked. Elevation and subsidence imply oscillation of the platform. Suppose for argument the island was originally formed by slow subsidence as Darwin requires, and at the end of that period elevation occurs by which beach rock is raised above the level of the sea. This would seem evident from the submerged cedars of Ireland island must have been submerged before the elevation of the beach rock, for if not they would be lifted out of water. They were then, if submerged, sunken before the beach rock formed. If beach rock forms it would have been above them, for it seems not to have formed over the submerged cedars which "vessels bring up with their anchors from the Great Sound."

We have then this rather astounding condition, an island with cedar trees growing upon it is slowly submerged until the trees are under water. On the same island [i.e. platform] there is beach rock, confessedly formed under water, elevated above the sea. This beach rock was elevated before the submergence. It is impossible to be elevated after the submergence since it was formed under water, when the trees were above. Elevation after submergence would mean, if no other agent was present, bringing the trees to the surface again. It would have to be elevated before submergence if the movement was not local. The beach rock was therefore elevated before the submergence indicated by the trees. It must, at its highest point, have been much more elevated than the land on which trees stood, because although the submergence of the trees took place, the beach rock still remains in part above water.

Add now the depth at which trees are found to the hight of the beach rock above the sea level and we would have at least a part of the amount of elevation of the top of the beach rock. If the elevation was equal throughout the whole area of the platform it would be high enough to raise the platform out of the water completely before its submergence. Reasoning from these data there would seem evidence to conclude that even without its capping of æolian coral limestone Bermuda was once practically a *continuous* island from North Rocks to the present inhabited islands. But these remarks offer no proof of a subsidence of the platform before the elevation.

The submerged cedars if they prove subsidence can only be interpreted as indicating a subsidence after the elevaelevation but not before. We are, it seems to me, obliged to rely on purely theoretical grounds for a preceding subsidence, provided the data for elevation are correct.

There is no difficulty in accepting the theory of erosion to account for the disappearance of the old Bermuda on the ground of the great quantity of eroded material. A parallel can be found in our western cañons and eroded table mountains where, although conditions are very different, water has played such a tremendous part in a somewhat like process. The depths of the Atlantic contiguous to the island could well be the dumping place for the eroded material carved out of the old island.

The depth of Harrington sound at certain points does not seem a fatal objection to the erosion theory unless it can be shown that the erosive power of water is limited to a shallow was being deposited. I think t latter expl true one and that here we have something akin t of the mouths of rivers by the detritus which th from their valleys. Whence came that de Flatts"? Manifestly it is the result of erosion portion of the products of erosion is thus d course to the ocean, a still larger amount manif into the ocean. The amount of ground up c can be transplanted by ocean currents can (appreciated by one who remembers the mile white water which are often seen in the vic islands.

The problem which we are considering deals ent configuration of the islands of the Bermuda line may or may not correspond with that whi former times. Roughly speaking it may be sai eral way the contour of the old Bermuda befo eaten out the lagoons, was that of an oval islan may have been in the process of elevation or and if the latter, depressions in it may have be from which the sound begins to form. Eve possibilty of submergence, bringing this depr the ocean level does not mean either that we ac that the contour of the present sounds are du ence, except in a very general way.[4] The imme the circular lagoons is what we are after, an thought to be erosion, even if subsidence, local taken place. With those who hold that subsid place in the Bermudas I have no important diff It is only with those who adduce from tl subsidence and formed as are the Pacific atolls that I find myself holding a different view.

How much the Bermuda platform under the sea has been lifted up by elevation of a mechanical nature we can probably never know, but the amount of growth of the land above the ocean, formed by upheaval and by other forces we can discover. The thickness of the æolian limestones, due to wind action upon finely triturated sand, is much greater than the highest estimate of upheaval as indicated by elevated beach rock. Roughly speaking it may be said to be over three times as great, as far as has been at present observed. It is but natural to conclude that these wind-blown sands and the rocks formed from them have played their share, which is not small, in the formation of the island. They have done more than elevation to determine subordinate features of the configuration. Æolian rocks can not form under water, and yet there are high wind-blown rocks in perpendicular cliffs in at least one point on Harrington sound. When these rocks were first formed their sides were not as precipitant as at present, when they show evidences of tremendous erosion.

This soft rock occupying now, after great denudation, three times the thickness of all the rock above water, has suffered most in denudation, since it is one of the softest known rocks. What must have been its proportion of loss since the erosion began? Enough I fancy to impart the shape to the land above water on the oval platform, irrespective of any atoll shape which the up heaved rock may originally have had. It practically has modified the old form of the island. Then, when denudation combined with this under the form of a new mask, obscured the outlines derived from elevation and subsidence, this was the rock, which suffered the most, and which, even in the destruction of its character as rock has the greatest influence in determining the outlines of the coast. A capping of rock so soft as to feel every imprint of eroding forces, now in the form of sandstones, now as a moving glacier carried by the wind, transported by water, is the formation to which Bermuda owes its outlines. Its influence in the modification of coast lines of Bermuda is greater than subsidence, which in a measure it neutralizes.

Some of the conclusions arrived at in my study of the origin of the coast lines of the Bermudas have a general application to a classification of ring-shaped coral islands.

While it is customary to call all ring-shaped coral islands atolls, it seems to the author that the practice has led to a misconception in assigning the same causes for their similar shapes. Ring-shaped coral islands may be true atolls, as those of the Pacific, or ring-shaped like the Marquesas group of the Florida Keys. Still others may be typified in ring-shaped islands derived from previously existing coral islands by erosion. Of these Bermuda is a type and an excellent illustration. What its original form was when it emerged from the sea we do not know. Speculation and comparison with other coral islands would lead us to regard it as circular. But since the appearance above the surface of the sea it has been profoundly affected by other forces which have greatly modified it and changed its contours. The island has passed through a geographic development or a life-history in which the work of erosion fills much of the last chapter, for coral islands have an initial form characteristic of growth and a final form resulting from erosion. The former are coral islands in the process of active development; the latter of denudation or decay.

NOTE ON SOME OF THE CAUSES OF EXTINCTION OF SPECIES.

J. M. McCREERY, Akron, O.*

Facts concerning the life history of the various forms of life whose fossil remains are found in every stratum of the more than 5,000 feet of limestones, shales and sandstones that make up the geological column as exposed in Ohio, are always of interest to students of Ohio geology.

Some species made their appearance and continued to exist while hundreds of feet of sediment were deposited. Other species seem to have come abruptly upon the scene and after a brief existence—geologically speaking—but which represents vast cycles of time as men reckon years—disappeared, and were replaced by later forms. The list of American palæozoic fossils now numbers not less than 10,000 species and is being added to every year, yet not a single one of these species is living to-day.

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* This paper is extracted from an address delivered before the Akron Scientific Club on Jan. 8, 1890, on "Losers in Life's Race."

Between 250 and 300 fossil forms have been recognized in the 800 feet of limestone and shales known under the general name of the "Cincinnati group" and by following "the testimony of the rocks" we may learn something of the life history of at least a few of this long array of species.

In the Trenton limestone, the lowest rock exposed in Ohio and the formation in which natural gas is obtained, there is found a fossil brachiopod shell, *Orthis biforata.* It occurs very sparingly in the fifty feet exposed at Pt. Pleasant, Clermont county, and is seldom or never met with in the lower portion of the next higher deposit, the Cincinnati beds. But in the upper portion, at the hight of 300 feet above low water mark of the Ohio river, this fossil becomes quite common. It is, however, a smaller shell and so different from the typical form that it is classed as a variety of *O. biforata* under the name of var: *dentata.* About 50 feet higher or 350 feet above low water, it has reached the full *size* of the typical *O. biforata* but does not show all its peculiarities and is known to science as var: *lynx.* At the hight of 425 feet it assumes all the characteristics of the typical American form of *O. biforata* and becomes so numerous that a stratum from 2 to 10 feet in thickness and spreading over miles and miles of extent is made up almost entirely of the full grown shells of this fossil, and so certain is this layer to be found where the proper hight is reached that it is regarded by geologists as a most reliable land-mark. When the "*O. biforata* stratum" is found the geologist knows that he is near the top of the Cincinnati beds.

O. biforata did not die out after thus becoming so numerous, but continued in diminished numbers through the Lebanon beds, the uppermost member of the Cincinnati group and on up through both the Clinton and Niagara groups—the former with a thickness of 50 and the latter with a thickness of 350 feet, or a combined thickness of 400 feet. This added to the 300 feet which constitute the Lebanon beds, the 425 feet of Cincinnati beds, and the 50 feet of Pt. Pleasant beds (now recognized as Trenton) gives us a total combined thickness of over 1200 feet of limestone and shale, and during the vast ages in which it was being deposited this particular species continued to exist.

As a contrast to the life history just given is that of the fossil *Strophomena plano-convexa*, also found in the Cincinnati group at Cincinnati,[1] at an elevation of 300 feet above low water. While this species lived long enough to spread itself over the entire bottom of the sea in which the Cincinnati group was deposited, it is only found through a few feet in thickness of the 800 feet of limestone and shale that are included under this general name. *Orthis retrorsa* is another fossil brachiopod that makes its appearance in the same limestone at the hight of 475 feet above low water, but is only found for a foot in thickness—when, so far as known, it disappears entirely. Yet, judging from the character of the rock or the other fossils associated with this, there was no physical change of any kind that marked its appearance or disappearance.

The trilobites furnish us with a stranger story of life and death—death not only of the species but of the whole family, so that to-day they have not a living representative in the world. They made their appearance in the Primordial period, increased in the Lower Silurian, were most numerous in the Upper Silurian and "after there had been, under a succession of genera, more than 1700 species, came nearly to an end with the Devonian—the old genera being all extinct and only three new ones appearing in the Carboniferous to close off this prominent Palæozoic type." (Dana's manual of geology, page 289). Although these lingering forms carry the life history of the trilobites to the close of Palæozoic time, yet the fact remains that the end of the Carboniferous age saw their final extinction.

The question naturally presents itself, What caused the extinction of species in past geological ages? Let me say here that no one great cause need be sought, but rather a vast number of slight and almost imperceptible ones. A case once came under my own observation that well illustrates to what slight changes we must look for information on this subject Ten years ago I made a trip to the Tuscarawas river four miles south of this city, (Akron, O.) for the purpose of obtaining some specimens of a river mussel, *Unio clarus*, not found in streams flowing north into lake Erie. There had been a summer freshet some days before, but the water was then low. I found thousands of dead shells but not a single live one in four miles walking in the bed of the stream. The fresh water mussels bury themselves with one end of the shell just projecting above the sand and gravel, and the end in which the openings are located directed up stream. The valves are usually slightly parted so that the water may enter through one siphon and after the animalcules, etc., contained in the water have been strained out by the gills of the mussel, the water is forced out through the outlet siphon. But the summer freshet had washed so much sand into the opening of the shells that the mussel was unable to close the valves, and so an animal that spends its whole life in the water was drowned in its native element. Visits to the locality several times since show that they have not yet recovered their former abundance, and nothing would be necessary to totally extinguish all the species of Unio in northern Ohio but frequent summer freshets continued from year to year.

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[1] "The Cincinnati Group," Prof. Orton Geological Survey of Ohio, vol. I, page 393.

A few years ago about three miles south of this city there was a swamp in which a particular species of snail *Helix mitchelliana*, was found. It has not been found elsewhere in northern Ohio up to this time so far as known. To say that it was plentiful gives but a faint idea of its abundance. Perhaps the fact that at one visit of a couple of hours I collected more than a quart may give an idea of the numbers. Three years after the discovery of this interesting colony a ditch was dug round the swamp which drained the surface of the field and cut off the supply of water from the water-loving plants which covered its surface, causing the death of the swamp vegetation. As this snail is a vegetarian, the disappearance of the swamp vegetation may have destroyed its supply of food, or the lack of proper shelter, or more likely a combination of many slight causes may have exterminated it: at any rate the snails totally disappeared and the most careful search all round the vicinity has failed to find a single specimen since.

Five or six years ago in one of the lumber yards of this city there was a minute species of snail, *Pupa corticarica*, not yet elsewhere reported in this vicinity. It had probably been introduced here attached to pine lumber from Michigan where this species is common. The surface of the lumber yard was filled in with refuse two years ago and the snails were buried and are now only known to have ever occurred here from the specimens in the various cabinets in this city.

In both the latter cases man's agency was at work in the extinction of species, but in the case of the shells in the Tuscarawas river man played no part.

These instances may serve to remind us that in palæontology as at present we need not look for cataclysms and convulsions to account for the extinction of species, but must often attribute them to local changes, slight but sufficient, in the keen struggle for existence, to handicap the losers in the race.

AN ATTEMPT TO EXPLAIN GLACIAL LUNOID FURROWS.

By A. S. PACKARD, Providence, R. I.

In his admirable report on "the rock-scorings of the great ice invasions" in the seventh report of the U. S. geological survey Prof. T. C. Chamberlin draws attention to the subject of lunoid furrows, and rejects my explanation of the cause. It may be said that the first observer to call attention to these crescentic ice-engravings was Dr. John Delaski, of Maine, (I think Falmouth or Yarmouth) who saw them on Mt. Desert, and described them in the American Journal of Science for Sept., 1863, (2d Ser. xxxvi. 275).

Having observed these ice-marks, at various places in Switzerland the past summer, and not having been satisfied with my former explanation, I venture to suggest what may seem to be a more reasonable one. It also appears that the lunoid furrows are apparently the same as Prof. Chamberlin's "crescentic gouges."

I first observed them at the Gletschergarten of Lucerne, where they are not, however, very well marked, as the rock is a limestone, and not favorable for their best development. The photograph which I obtained quite closely resembles Prof. Chamberlins' fig. 33 of the disruptive gouges in sandstone, at Amherst, Ohio. Besides the gouges or true lunoid furrows, the limestone rock at Lucerne was in places more or less scaled off irregularly, as if the result of pressure. The surface was inclined, the ice having been apparently forced locally uphill. Afterwards in walking up the Grimsel Pass, these lunoid gouges were observed in abundance on the granite spur or shoulder near the head of the pass, where steps are cut into the smooth, polished and glaciated surface. This is one of a series of spurs which extend out into the valley, from Handeck to the Grimsel Hotel, and judging from their highly glaciated surface, they must have been subjected to tremendous pressure. Moreover at this point the granite showed a strong tendency to exfoliate, leaving more or less crescentic hollows. But on the next day when going and returning from the Aar glacier and passing a glacially smoothed and polished nubble of granite which stood directly in the former path of the glacier, about half an hour's walk from the hotel, the probable cause of the numerous lunoid gouges so well developed there, occurred to me. It seemed quite plain to the minds of myself and my son, who accompanied me, that the transverse gouges were due to great pressure, causing the granite surface to exfoliate, while the quite regular shape of the gouges was due to the presence of rounded subglacial boulders[*] of different sizes which were forced along between the ice and the surface of the rock. The gouges were on the stoss or glacial inclination of the nubble, the ice locally moving uphill. My former attempt at explaining the process by local back-and-forth motion of the ice, so as to cause the stones to turn over I was led on the spot to abandon. The marks both above Handeck, and in the Aar valley were identical with those I had many years previously noticed on the coast of Labrador, and near the summits of Mt. Baldface and Speckled mountain, and at another point near Goodrich's falls on the Ellis river in the White mountains. The gouges there, appear usually to occur on surfaces which presented unusual obstacles to the passage of the ice, and are best developed on granite rock-surfaces, which have a tendency to exfoliate, and they seem to be caused by the presence of one or several boulders. The curved and crescentic or gouge-shape of the mark appears to be due to the fact (1) that the glacier carried or pushed a more or less angular boulder over a granite nubble or spur, so that the pressure was greater than at other points in the valley; (2) the more or less rounded boulder, with its lower or under side perhaps somewhat flat, and so situated that the ice rested only on the top, occasioned greater local pressure than where no boulders were present; (3) the boulder meeting with a slight obstacle suddenly stopped, and the ice pushing it from behind caused it to slightly tip, so that an immense pressure was brought to bear on the small surface, causing the formation of a gouge-like crescentic hollow, with the concavity towards the origin of the motion, i. e., facing up the valley.

In making my first explanation I wrongly inferred that there might be an "advancing and receding motion of the glacier," so as to cause the stone to turn over.

In some way, then, due both to the striking or pushing force of the glacier, and to the local pressure resulting from the presence of a boulder between the ice and the rock surface, the boulder was not as with the rest of the ground-moraine pushed gradually and slowly onward, but hitched, thus causing it to break off the lunoid fragment on a surface peculiarly liable, under great local pressure, to exfoliate.

Prof. Chamberlin remarks that he has not seen any "lunoid furrows." What, however, we call lunoid furrows are apparently identical with his "crescentic gouges" or "disruptive gouges" such as are represented by his fig. 34. In fact my photograph of the glacier garden at Lucerne, with the crescentic gouges is almost identical in appearance with his fig. 74.

EDITORIAL COMMENT.

THE AZOIC SYSTEM.

The following is quoted from the new Century dictionary:

> The "Azoic system" or series of Foster and Whitney includes the stratified rocks, together with the associated unstratified ones which underlie unconformably, or are otherwise shown to be older than the Potsdam sandstone, or the lowest group of rocks which has up to the present time been proved to contain traces of a former organic life.

The following is quoted from Foster and Whitney's report on the lake Superior land district, 1851, Part II, p. 3:

> Below all the fossiliferous groups of this region there is a class of rocks, consisting of various crystalline schists, beds of quartz, and saccharoidal marble, more or less metamorphosed, which we denominate the AZOIC SYSTEM. This term was first applied by Murchison and Verneuil to designate those crystalline masses which preceded the paleozoic strata. In it they include not only gneiss, but the granitic and Plutonic rocks by which it has been invaded. We adopt the term, but limit its signification to those rocks which are detrital in their origin, and were supposed to have been formed before the dawn of organized existence.

The definition from the dictionary is seriously defective. It will be noticed that it includes the unstratified rocks, in the

same manner as Murchison and Verneuil, but that by Foster and Whitney these are specially exempted. The Azoic system, as defined by Foster and Whitney, would be the equivalent, nearly, of the recently named Keewatin and Vermilion groups, and, until fossil remains have been found in the Animike (Huronian), it would also be considered to embrace that. If the Animike be finally shown, as suspected, to be the equivalent of the "Olenellus beds" of the Taconic, it would have to be excluded from the Azoic. There is a pliability consistent with possible future discovery, in the definition of the Azoic by Foster and Whitney. But this is wanting in the Century definition. According to it the Azoic rises to the Potsdam sandstone; and the remarkable statement is made that it (we understand the Potsdam sandstone) is "the lowest group of rocks which has up to the present time been proved to contain traces of a former organic life." Shades of Emmons and Barrande! What can now be done with the "Olenellus beds?" Where shall Linnarson and Brögger, and Nathorst, and Salter, and Hicks, and Walcott, and Ford, and Matthew now assign the great fauna that they have discovered in strata below the Potsdam.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Contributions to the micropaleontology of the Cambro-Silurian rocks of Canada, Part II. E. O. Ulrich. Geol. Sur. of Canada, 1889.

The paper describes specially some polyzoa (bryozoa) and Ostracoda from Manitoba, the new forms being Monticulipora parasitica var. plana, Diplotrypa westoni, Batostoma manitobensis, Petigopora scabiosa, Bythopora striata, Fistulipora ? laxata, Gomotrypa bilateralis, Pachydictya hexagonalis, and P. magnipora, Ptilodictya whiteavesi. Leperditia subcylindrica, Primitia lativia, Primitia (? Beyrichia) parallela, Eurychilina reticulata, and E. manitobensis, Strepula lunatifera. The forms are illustrated by two plates.

The fossils from Stony mountain indicate the upper part of the Hudson River group. Those from St. Andrews indicate the Trenton.

Kentucky fossil shells, from the Silurian and Devonian rocks of Kentucky. By Henry Nettleroth. Kentucky Geological Survey. J. R. Proctor, director, 4to, pp. 295, and 36 plates of fossils, $5.00. Robert Clarke & Co., Cincinnati, O., and John P. Morton & Co. Louisville, Ky.

This monograph contains a short sketch of geology and palaeontology, giving the outlines of both sciences, explaining the principles upon which they rest, and forming a short introduction to both subjects. It is written in a simple manner, free from abstract technical terms, and well supplies the want of the general reader interested in science.

The descriptions and figures of the mollusca, from the region of the Ohio falls, are scattered in various publications and almost out of reach of the palæontologist. The author has gathered this widely dispersed material, and, with but few exceptions, redrawn all figures from the numerous and finely preserved fossils of his cabinet. To this he has added the new material obtained during long years of collecting, making the volume a monograph of exceeding value. It is illustrated by 36 lithographic plates, containing 220 species, of which 43 are new.

Contributions to Canadian Palæontology, Vol. I, Part II. J. F. WHITEAVES. Montreal, W. F. Brown & Co., 1889.

In this part Mr. Whiteaves continues his investigations upon the Canadian (almost exclusively invertebrate) palæontology. In article 2, "On some fossils from the Hamilton of Ontario, etc." there are described the following new species—two crinoids, *Homocrinus crassus*, and *Dolatocrinus canadensis* and one doubtful *Megistocrinus* species, one doubtful blastoid *Pentremitidea filosa*, two brachiopods *Lingula thedfordensis* and *Spirifera subdecussata*, one gasteropod *Platyostoma plicatum*. A list is also given of all the known species from the Ontario Hamilton as follows:

Spongiae	g. 1. s. 1.	Brachiopoda	g. 16. s. 41.
Anthozoa (Alcyonaria)	g. 2. s. 5.	Lamellibranchiata	g. 2. s. 2.
(Zoantharia)	g. 14. s. 31.	Gasteropoda	g. 3. s. 8.
Hydromedusae	g. 2. s. 3.	Pteropoda	g. 1. s. 1.
Crinoidea	g. 7. s. 9.	Cephalopoda	g. 2. s. 3.
Blastoidea	g. 5. s. 5.	Crustacea (Ostracoda)	g. 1. s. 1.
Vermes	g. 6. s. 13.	(Trilobita)	g. 2. s. 3.
Polyzoa	g. 12. s. 21.	Pisces	g. 1. s. 1.

In article 3, "Fossils of the Triassic Rocks of B. C.," nine new species are described, two brachiopods, *Spiriferina borealis*, *Terebratula liardensis*; three lamellibranchs, *Monotis ovalis*, *Halobia occidentalis*, *Trigonodus (?) productus*: one gasteropod, *Margarita triassica*, four cephalopods, *Nautilus liardensis*, *Popanoceras mcconnelli*, *Acrochordiceras (?) carlottense*, *Trachyceras canadense*: Hyatt's new genus (*Arniotites*) is described at length.

In article 4, "On some Cretaceous fossils from B. C. the N. W. Territory and Manitoba" one new lamellibranch, *Astarte carlottensis* is described from B. C., two brachiopods, *Discina pileolus*, *Terebratula robusta*: two lamellibranchs, *Cyprina yukonensis*, *Lima perobliqua*; three cephalopods, *Schloenbachia borealis (?)*, *S. gracilis*, *Placenticeras glabrum*: one phyllopod, *Estheria bellula*, from the N. W. Ter. and *Serpula semicoalita* (Vermes) *Modiola tenuisculpta*,[1] *Belemnitella man-*

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[1] According to Mr. Whiteaves this species appears to be closely related to *Volsella multilinigera*, Meek, from the Cretaceous of Utah, the umbonal slopes in the former being more broadly rounded and the anterior extremity more greatly prolonged beyond the beaks.

itobensis, *Loricula canadense* (cirripede) and two selachian fishes *Ptychodus parvulus*, *Lamna manitobensis*.

The work is beautifully illustrated with fifteen plates of sixty-three species.

On the form and position of the sea level, with special reference to its dependence on superficial masses symetrically disposed about a normal to the earth's surface. By ROBERT SIMPSON WOODWARD. pp. 88. (Bulletin of the U. S. Geological Survey, No. 48, 1888). The mathematical investigation here reported deals with the influence on the level of the sea or of lakes exerted through gravitation by such masses as the ice-sheet of the Glacial period, or in a lake basin by the water itself. Its application in the present work of the national survey is to determine the amount of displacement or variation from the present level which would be thus accounted for in the shore lines of the Quaternary lakes Bonneville and Lahontan of the glacial lake Agassiz and the higher stages of the Laurentian lakes, held in on the north and northeast by the receding ice-sheet, and of the ocean, which submerged the northern borders of this continent and of Europe at the close of the Glacial period. The previous discussions of this subject by Pratt, Heath and Thomson are reviewed; and the formulas deduced for ice attraction are employed in a consideration of the variations in sea level attributable to continental masses.

The next two in this series of bulletins are by the same author: No. 49. *Latitudes and longitudes of certain points in Missouri, Kansas and New Mexico*, (pp. 133, 1889), consisting chiefly of instrumental observations and their computation; and No. 50. *Formulas and tables to facilitate the construction and use of maps* (pp. 124, 1889).

On invertebrate fossils from the Pacific Coast. By CHARLES A. WHITE. pp. 102; plates 14. (Bulletin of the U. S. Geol. Survey, No. 51, 1889). Part I of this memoir describes nineteen new species and one new genus of fossil mollusca from the Chico-Téjon series of California. This series, which comprises the Chico, Martinez, and Téjon groups of the California Geological Survey, is found to be one great continuous succession of marine strata, unbroken from base to top, though representing both the closing epoch of the Cretaceous period and the opening one of the Tertiary. "During this time," writes Dr. White, "attendant physical conditions produced no sudden changes in the aqueous life of the waters in which the deposits occurred. * * * * The Cretaceous characteristics gradually disappear upward leaving the surrounding fauna, with its later accessions, without any commingling of Cretaceous types." These features present a marked contrast with the probably contemporaneous brackish and fresh-water Laramie formation of the interior of the continent, which, although doubtless continuously deposited from the marine Cretaceous beneath it, and into the fresh-water Tertiary deposits above it, yet exhibits, because of surrounding physical changes, an abrupt accession of its peculiar aqueous fauna at its base and almost as abrupt an extinciont of it at the top.

Part II notes the occurrence of equivalents of the Chico-Téjon series in Oregon and Washington. These represent both the lower or Chico portion of the series and the upper or Téjon portion. Only the former, however, is identified in southern Oregon and northern California.

Part III discusses the fauna of the Vancouver group, describing three new species. This formation is shown to be palæontologically equivalent, at least in large part, with the Chico strata.

A small, unique fauna, collected by professor Newberry from the coal-bearing formation of the Puget Sound basin, is reported in Part IV, indicating deposition in a very large estuary, which was probably contemporaneous with the Laramie sea.

The closing article, Part V, notices a small collection of Mesozoic fossils from Alaska, all of which are regarded as new, and as probably belonging to strata somewhat older than the Aucella-bearing strata of Alaska.

Subaerial decay of rocks and the origin of the red color of certain formations. By ISRAEL COOK RUSSELL. pp. 65; plates 5. (Bulletin of the U. S. Geol. Survey, No. 52, 1889). In the study of the origin of the prevailingly red color of the Mesozoic sandstones and shales of our Atlantic border on the bay of Fundy and from the Connecticut valley to South Carolina, named the Newark system,[1] Mr. Russell has examined the areas of deeply decayed rocks, covered with red soils, in the southern states, and compares them with similar rock decomposition and residual soils of other parts of the world.

The mica schists and allied rocks in Pennsylvania and Maryland are decayed to the depth of only a few feet, but are frequently disintregrated, that they may be removed with a pick and shovel, to fifteen or thirty feet, and occassionally fifty feet, below the surface. Nearly the entire area underlaid by crystalline rocks in Virginia and the Carolinas east of the Blue Ridge has a soil of red clay, which is a residual deposit produced by the subaërial alteration of the rocks on which it rests. This alteration generally reaches more than a hundred feet, below the surface, but, owing to lack of exposures, its full extent is seldom seen.

On washing the residual deposits so as to collect separately their grains of quartz and feldspar, scales of mica, and particles of other minerals, each of these sand grains, especially where the decomposition is well advanced, has been found to be coated with a thin shell having a brownish or red color. Prolonged washing fails to remove this coating, a fact which is well illustrated by the red sands now being deposited by the streams of Virginia and the Carolinas in the regions underlaid by crystalline rocks. Chemical analyses show that the incrustation is rich in both ferric oxide and alumina, being a ferruginous clay formed around the individual grains during the disintegration and decomposition of the parent rocks.

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[1] See this journal, vol. III, pp. 178-182, March, 1889.

Warm, moist climates are most favorable to rock decay, which is found more general and extending to greater depths as one travels from north to south along the crystalline Piedmont belt of Archæan age or in the great Appalachian valley of Palæozoic strata. Along the Shenandoah, James and New rivers in Virginia the decay of limestone has yielded a red clay sometimes fifty feet deep; but in the colder and somewhat less humid climate of the driftless area in Wisconsin the average thickness of the residual deposits is only seven feet. Little decomposition of the rocks is observable in the arid region of the Rocky mountains and the Great Basin, and the colors of the soils there are gray and light brown; but on the west slope of the Sierra Nevada, which has plentiful rains and temperature nearly like that of the southern part of the Appalachian belt, deep rock decay has taken place and the soil is red. In Nicaragua, the West Indies, Brazil and southern Europe and Asia, extensive rock decomposition and red soils prevail. The red earth of Bermuda, the "terra rossa" of southeastern Europe and the "laterite" of India are apparently identical, both in composition and in method of accumulation, with the red residual soil of the south part of the Appalachian valley.

Turning to the rock formations of previous eras, we find that the red and brown colors of the Newark sandstones, and of many other sandstones, as on lake Superior, are due to incrustations of ferric oxide which coat the surfaces of the grains of quartz and feldspar forming the strata and cement them together. The author therefore concludes that these beds consist of the débris of lands that had long been exposed to the action of a warm, moist atmosphere. Previous hypotheses of Ramsay, Dawson, Dana, Cook, Newberry, Newton, Green and others, are discussed; and there is appended a bibliography of papers relating to the subaërial decay of rocks.

The geology of Nantucket. By NATHANIEL SOUTHGATE SHALER. pp. 54; with ten plates and 16 figures in the text. (Bulletin of the U. S. Geol. Survey, No. 53, 1889). Glacial and recent deposits form the entire island of Nantucket. Through its central part there extends from west to east a series of low but extremely numerous and irregularly shaped hills of glacial drift (gravel and sand with boulders), culminating in Shawkemo, Altar rock, and Foulger's hills, and Sankaty Head, 75 to 100 feet above the sea. On the southern half of this island this line of low drift hills, which is shown by its topographic features and material to be a terminal moraine of the continental ice-sheet, is bordered by a plain of gravel and sand which descends with a gentle slope from the hills to the sea and terminates in low bluffs rarely more than 20 feet high.

The lowest deposit exposed on Nantucket is a bed of clay, generally blue and compact, scantily intermingled with pebbles and sand. Though exhibiting an obscure stratification, it is probably to be classed as till or boulder clay. Its pebbles are occasionally scratched, and throughout they have the angular or faceted character common to glacial pebbles. When considerable sections are exposed, as is the case at two or three points, the upper part of the deposit for 15 or 20 feet is seen to be altered to a yellowish or grayish color, while the mass below is of the characteristic blue color of such clays. This formation does not rise above the level of the sea save in a small portion of the surface of the island. Its highest point seen is in an excavation for road material in the west part of the village of Nantucket, where it rises about 30 feet above the sea.

Upon the undulating surface of the lower clay lies a mass of irregularly stratified sand and gravel, shaped in the hillocks and short, tumultuously grouped ridges called kames, with prevailing trends east and west and enclosing occasional ponds or swamps in the intervening hollows. Where the hills are steepest, often having slopes of 20° to 30°, they usually are very stony, large angular blocks being scattered over their surfaces, which, with the peculiar contour, show clearly that this belt is part of a frontal moraine.

The most peculiar feature of the southern plain is found in broad channels extending from the moraine to the ocean shore. These channels are digitate, two or more often uniting in their southward course. They range from 5 to 20 feet in depth, and have flat bottoms from 200 to 800 feet wide, sloping toward the sea with an irregular descent of about five feet in a mile. Their seaward extremities are in all cases below the level of the ocean and contain lagoons or ponds which are barred from the ocean by beaches of sand.

Evidences of decay are observable in the pebbles of these drift deposits, by the crumbling of many of the varieties of crystalline and fragmental rocks, by the dissolved look of the surface of the rocks which resist interstitial decay, and by the development of joint planes in the pebbles, so that, though they may be but little decayed, they often split into fragments on being removed from their bed. Professor Shaler believes these changes to be twice or three times greater than in more northern localities, as about Fall River, Mass., or on the coast at Boston and northward. But the suggestion that the drift of Nantucket has been proportionately longer exposed to subaërial weathering, and that the recession of the ice-sheet from Nantucket was twice or thrice as long ago as from northern New England, seems unwarranted; for the outer portion of the drift would contain a large intermixture of preglacial gravel from stream beds and the sea shore, and of other superficial deposits that covered the country before the ice age, all of which had already been long subjected to weathering, so that these characters of the pebbles may have been acquired then. On the other hand, the drift farther north, where glacial erosion and transportation were more efficient, would scarcely include any pebbles formed by preglacial weathering, and stream and sea erosion, and its rock fragments, derived by glacial planation and plucking from the bed-rock, would exhibit only that slight weathering and chemical change which they have received during post-glacial time.

The same consideration may also explain much of the difference in these respects between the outer part of the drift along all the glaciated area of the United States and that lying farther inside the glacial boundary, as within the terminal moraines of the upper Mississippi region.

In all the pebble-drift sections of Nantucket, Prof. Shaler finds plentiful subangular rock fragments, with the fractured edges only slightly worn, some of which closely resemble palæolithic implements. He regards these as indicative of a long interval between two ice incursions, the earlier bringing boulders and pebbles in which joints and cracks were subsequently developed, and the later ice-sheet breaking these masses and strewing their subangular parts in its drift. Another explanation, however, seems to be afforded by the probable occurrence of such joints and cracks in preglacial gravel or shingle and in masses left during the disintegration of ledges, so that there may have been only a single glacial advance to Nantucket.

The richly fossiliferous post-Pliocene beds in the lower part of the section of Sankaty Head, on the east shore of the island, were first examined by Messrs. Desor and Cabot. Afterward more full collections, and the discrimination of two shell-beds separated by a Serpula layer, were made by Messrs. S. H. Scudder and Richard Rathbun, the species being determined by Prof. A. E. Verrill, whose list and notes are here copied in full. The lower shell-bed contains about thirty-five species which make up a faunal group of distinctly southern character, all of them being now found living on the southern shores of New England, but several having their northern limit at Cape Cod. The species of Serpula is also of southern range, reaching from this limit to North Carolina. The upper shell-bed has about the same number of species as the lower, but only thirteen are common to both. The new species brought in by the upper bed are mostly of northern range; though all of these are found as far south as Massachusetts Bay, several of them have their southern limit here or on the south coast of New England. The differences, however, according to Prof. Verrill, may not be due to any general climatic change in the temperature of water or of air, but rather to geographic modifications of the low shores and shallow sea in this vicinity, by which this place, for a time sheltered, became later exposed to cold marine currents and the surf of northeast storms. The only similar preglacial or interglacial fossiliferous section along the whole drift-bearing portion of our Atlantic coast is on the shore of Gardiner's island, about sixty miles distant to the west.

Professor Shaler believes that during the formation of the terminal moraine on Nantucket this area was submerged so that its hill tops were some 200 feet below the level of the sea. This he thinks to be shown by the boulders strown over the morainic kame deposits, which he supposes to have been dropped from icebergs, and by the contour of these deposits, which are not only destitute of lines of shore erosion or of beach accumulations, but were submerged so deeply, if this hypothesis be true, that their outlines, as heaped under the sea along the edge of the ice-sheet, were not remodeled by the waves of great storms. After the departure of the ice, this island was uplifted according to Prof. Shaler, not less than 300 feet, that is, to its present level or higher, with paroxysmal suddenness, the time occupied in this movement being surely not so long as even a few days, else the moraine and its frontal terrace plain would be marked by unmistakable shore lines. The channels extending across the plain from the moraine to the sea, with their bottoms running below the sea level, are thought by this author to have been cut by submarine streams out-flowing from beneath the ice-sheet.

An alternative hypothesis, which should be compared with the foregoing, is held by Mr. Warren Upham, who some ten years ago studied the geology of this island, publishing his results in the American Naturalist for August and the American Journal of Science for September, 1879. He thinks that this moraine, while it was accumulating along the ice-border, was even higher above the sea than now, and that the channels extending from it southward and passing beneath the ocean level were then eroded by the floods discharged during the summer melting from the surface of the ice and thence flowing down to the sea. According to this view also, Martha's Vineyard and Long Island, which show similar stream-courses crossing their southern plains from the terminal moraine to the sea, stood likewise higher when their drift deposits were formed. Furthermore the absence of shore lines and of fossiliferous marine beds overlying the glacial drift indicates that no portion of these areas has been submerged and re-elevated since the retreat of the ice.

At the present time there is known to be a slow depression of the land in progress along the greater part of the coast from New Jersey to Cape Breton island. Professor Shaler in this memoir shows, by submerged beds of peat and the stump of a tree rooted where it grew, that this recent depression in Nantucket has amounted at least to five or six feet. It appears, however to be more than this, from the following statement in the Quarterly Journal of the Geological Society, London, vol. XVII, 1861, p. 382: "In the harbour of Nantucket there is a submarine forest. In dredging the estuary, Lieutenant Prescott found trunks and roots of the cedar, oak, maple and beach, some of them standing upright and still attached to the soil on which they flourished. The trees * * * * are eight feet below the level of the lowest tide."

RECENT PUBLICATIONS.

1. *State and Government reports.*

Bulletin of the University of Texas. Roads and material for their construction in the Black Prairie region of Texas. Robt. T. Hill.

Bulletin of the Museum of Comp. Zoology. The intrusive and extrusive Triassic trap sheets of the Connecticut valley. William M. Davis and Chas. Livy Whittle.

Bulletin of Wash. College Laboratory. Contributions to the paleontology of the plains. No. 1. F. W. Cragin.

Smithsonian Contributions to Knowledge. Genesis of the Arietidæ. Alpheus Hyatt.

2. *Proceedings of scientific societies.*

Acad. Nat. Sci. May-Sept. 1889, contains: Gadolinite from Llano county, Texas. E. Goldsmith. Description of new species of fossil Crustacea from the Lower Silurian of Tennessee, with remarks on others not well known. J. M. Safford and A. W. Vogdes. Chloanthite, Necolite, DeSaulesite, Annabergite, Tephrowillemite, Fluorite and Apatite, from Franklin, N. J. Geo. A. Koenig. Lower Carbonic gasteropoda, from Burlington, Iowa. C. R. Keyes. The American species of Polyphemopsis. C. R. Keyes. Spherodoma, a genus of fossil gasteropods. C. R. Keyes.

Proc. Can. Inst. The central basin of Tennessee, a study of erosion. William Kennedy.

Bulletin of the Minnesota Academy of Natural Science, Vol. III, No. 4, contains: Changes in the currents of the ice of the last glacial epoch in eastern Minnesota, Warren Upham; The topography and altitude of Minnesota (abstract). Warren Upham; Notes on the local geology of Mankato, A. F. Bechdolt; Evidences of early man in northeastern Minnesota, Geo. R. Stuntz; Some analyses of northwestern coals, James A. Dodge; Notice of the discovery of Lingula and Paradoxides in the red quartzytes of Minnesota, N. H. Winchell; Brief history of copper-mining in Minnesota, C. W. Hall; The lithological character of the Trenton limestone of Minneapolis and St. Paul, with a note on the boring of the West hotel artesian well, C. W. Hall; The geological conditions which control artesian well boring in southeastern Minnesota, C. W. Hall; Some notes upon the more recent fossil flora of North Dakota, and an inquiry into the causes that have led to the development of the treeless areas of the Northwest, John Leiberg; Description of maps showing the climate, geography and geology of Minnesota, Warren Upham. These were read between 1883 and 1886.

3. *Papers in scientific journals.*

Am. Nat. July No. The paleontological evidence for the transmission of acquired characters, Henry S. Osborn, *August No.* The Edentata of North America, E. D. Cope.

Can. Record of Science. On the occurrence of Leptoplastus in the Acadian Cambrian rocks, G. F. Matthew. Additional notes on Goniograptus thureani McCoy, Henry M. Ami.

Am. Jour. Sci. Jan. No. Devonian system of North and South Devonshire, H. S. Williams. Zinciferous clays of southwest Missouri, and a theory as to the growth of the calamine of that section, W. H. Seamon. Minium of Leadville, J. D. Hawkins. Mineralogical notes, W. P. Blake. Contributions to mineralogy, F. A. Genth. Origin of normal faults, T. M. Reade. A new stone meteorite, L. G. Eakins. On the barium-sulphate from Perkins' Mill, Templeton, Province of Quebec, E. S. Dana.

4. *Excerpts and individual publications.*

An obsidian implement from Pleistocene deposits in Nevada. W. J. McGee. *Am. Anthropologist.* Vol. II, No. 4, 1889.

The world's supply of fuel. W. J. McGee. *Forum.* Vol. VII. July, 1889.

Artesian wells in relation to irrigation in western Kansas. By Robert Hay. *Kansas State Board of Agriculture.* Aug. and Sept., 1889.

The preparation of Bernice anthracite coal. By Clarence R. Claghorn. (From vol. 3, *Ark. Geol. Survey* for 1888).

Notes on the Bernice anthracite coal-basin, Sullivan county, Pa. By Clarence R. Claghorn. (*Trans. Am. Inst. Mining Engineers*).

Indian potholes or giant's kettles of foreign writers. T. T. Bouvé. (*Proc. Bos. Soc. Nat. Hist.* vol. XXIV).

Description of a new genus and species of inarticulate brachiopod from the Trenton limestone. C. D. Walcott. *Proc. Nat. Mus.* vol. XII, No. 775, advance sheet, Dec. 10, 1889.

A fossil Lingula preserving the cast of the peduncle. C. D. Walcott. *Proc. U. S. Nat. Mus.*, 1888, p. 480.

Description of new genera and species of fossils from the middle Cambrian. C. D. Walcott. *Proc. U. S. Nat. Mus.* 1888, p. 441.

A simple method of measuring the thickness of inclined strata. C. D. Walcott. *Proc. U. S. Nat. Mus.* 1888, p. 447.

5. *Foreign publications.*

Sur le developpement des premiers trilobites. Par G. F. Matthew. (Ext. des annales de la Soc. Roy. Mal. de Belgique. Tome XXIII, 1888).

Contributions à l'étude des gneiss à pyroxène et des roches à wernérite. Par Alfred La Croix. Paris. 1889. Octavo. 280 pp., 2 plates and text figures.

Subaërial deposits of North America. I. C. Russell. From the Geol. Mag., July and August, 1889.

On the scratched and facetted stones of the Salt Range, India. Geol. Mag., Sept., 1889.

Bibliothèque géologique de la Russie. 1888. Composée sous la rédaction de S. Nikitin. Sup. to vol. VIII, des Bul. du Comité géologique.

Bulletins du Comité géologique. St. Petersbourg. Vol. VII. Nos. 7, 8, 9, 10; vol. VIII. Nos. 1, 2, 3, 4, 5.

Ueber die russischen Aucellen. Von J. Lahusen (mit 5 Tafeln). Vol. VIII. No. 1. Memoires du Comité géologique. St. Petersbourg. 1888.

Allgemeine géologische Karte von Russland. Blatt 139. Beschreibung des Central-Urals und des Westabhanges. Von Th. Tschernyschew. (mit 7 Tafeln und 61 Holzschnitten im Text). Vol. III, No. 4. Mémoires du Comité géologique. St. Petersbourg. 1889.

Glaciation of high points in the southern interior of British Columbia. Geo. M. Dawson. Geol. Mag. August, 1889.

Descriptions of eight new species of fossils from the Cambro-Silurian rocks of Manitoba. J. F. Whiteaves. Trans. Roy. Soc. Canada, vol. vi, Sec. IV, 1889.

On tachylyte from Victoria park, Whiteinch, near Glasgow. By Frank Rutley. Quart. Jour. Geol. Soc. November, 1889, vol. XLV.

The Foldtani Kozlöny (Sept.-Oct. 1889) contains: Sur le progress des récherches géologiques en Roumanie. Par. Bela de Inkey. Petrographische und géologische Verhaltnisse des centralen Theiles der Tokaj-Eperjeser Gebirgskette in der Umgebung von Pusztafalu, von Dr. Jul. Szadeczky. Zur Géologie Egyptens, von Joh. Janko jun.

On the sub-divisions of the Speeton clay. G. W. Lamplugh. Quart. Jour. Geol. Soc., November, 1889.

Die Hermannshöle bei Rübeland; geologisch bearbeitet von Dr. J. H. Kloos; photographisch aufgenommen von Dr. Max Müller; herausgegeben von der hertzoglich technischen Hochschule zu Braunschweig. Text und Tafeln.

Entstehung und Bau der Gebirge, erläutert am geologischen Bau des Harzes, von Dr. J. H. Kloos, pp. 90, 21 Figuren und 7 Tafeln, Braunschweig.

Bul. Soc. Imp. Naturalistes de Moscow. 1889. No. 1 contains: Etudes sur les couches jurassiques et cretacées de la Russie.—1. Jurassique supérieur et cretacée inférieur de la Russie et de l'Angleterre (Pl. II, III, IV); with a supplementary communication Sur les couches néocomiennes et jurassiques supérieures de la Russie et de l'Angleterre. A. Pavlow. Also Note sur le néocomien de la Crimée.

On fossil plants from the Mackenzie and Bow rivers. Sir J. William Dawson. 2 plates. From *Trans. Roy. Soc. Can.* vol. VII.

New species of fossil sponges from the Siluro-Cambrian at Little Metis, on the lower St. Lawrence. Sir J. William Dawson. 27 figs. and one plate. *Trans. Roy. Soc. Can.*, vol. VII.

Notes on Devonian plants. D. P. Penhallow. 1 plate. *Trans. Roy. Soc. Can.* vol. VII.

PERSONAL AND SCIENTIFIC NEWS.

WINTER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA. The first annual meeting of the Geological Society of America convened in the great hall of the American Museum at 10 A. M., December 26, and continued three days. There was a large attendance of fellows. The meeting was welcomed in a few words by Morris K. Jessup, Esq., president of the Museum, by whose invitation the Society had selected its place of meeting. President James Hall responded in some appropriate sentences. The reports of the secretary and treasurer showed that the Society consists of 175 fellows. Elections now announced raise the number to 190. About $1,750 are in the treasury, after paying all current expenses. Elections announced for 1890 are as follows:

President	JAMES D. DANA.
Vice-Presidents	JOHN S. NEWBERRY. ALEXANDER WINCHELL.
Secretary	J. J. STEVENSON.
Treasurer	H. S. WILLIAMS.
Councillors	J. W. POWELL. GEORGE M. DAWSON. C. H. HITCHCOCK.

Three fellows have deceased during the past year.—Prof. Geo. H. Cook, Rev. Prof. David Honeyman, and Chas. A. Ashburner, of whom the secretary read brief biographical sketches.

The first memoir presented was by president T. C. Chamberlin, on "Additional evidences bearing on the intervals between the leading glacial epochs." The so-called "Orange Sand" rests on the Tertiary. This contains no glacial pebbles, but only cherts derived chiefly from the Carboniferous. The pebbles are not Champlain, but preglacial. The lowest glacial member recognized he describes as the silts overlying the pebble beds, commonly known as löss. They are made up of particles of glacial products. They were originally horizontal and have received their undulatory configuration by the "creeping" of the materials of the hills which they mantle. The event was the great erosion of the Mississippi valley and of the river valleys tributary to it. The paper was discussed by McGee, Proctor, Morrill, I. C. White and Chamberlin.

The second communication was by professor Shaler, on "Tertiary deposits of eastern Massachusetts." He showed that since Miocene time there has been a great amount of mountain-building action in the district considered; and also that a part of the deposits which occupy the surface are not of glacial origin, but date back to the later Cretaceous. He discussed the complex structure of Gay Head' and pronounced most of the deposits Cretaceous. The paper was (briefly) discussed by G. K. Gilbert.

Dr. Newberry presented an oral communication on "The Laramie Group." He stated that the Laramie proper, as defined by King, is demonstrably Cretaceous—neither Tertiary nor formed of beds of passage. The Fort Union beds do not belong to it, but to the Tertiary. The proper Laramie does not, indeed, contain Tertiary plants, but forms analogous to those of European Cretaceous. The testimony of the plants and vertebrates is entirely harmonious; and that of the marine molluscs is quite in accord. The plants no one is authorized to pronounce positively Cretaceous or Tertiary; but nothing prevents our regarding them Cretaceous; the other evidences, however, are conclusive. The communication was discussed by Cope, Heilprin, Tyrrell, Ward and Stevenson. Cope stated that not only is the Laramie Cretaceous, but he is inclined to entertain the same opinion of the "Puerco" which lies above and contains 100 mammalian species. Thus the "Wasatch" would be the bottom member of the Tertiary.

Mr. S. F. Emmons read a lengthy and valuable memoir on "Orographic movements in the Rocky mountains;" but the reading, unfortunately, was mostly unintelligible to the audience.

Professor G. H. Williams presented some new facts proving the serpentine of Syracuse to be eruptive in origin. The evidences are: 1. It occurs as a dike cutting the Onondaga limestone, and slightly disturbing the contiguous strata; 2. Its inclusions are,(a) limestone fragments, (b) dark or black shale, probably of the Utica shale, a thousand feet below, (c) granite or gneiss; 3. The limestone inclosures are altered in zones parallel to the edges of the fragments. Discussed by Kemp, who stated that similar evidences of eruptive action occur near Ithaca.

Mr. I. C. Russell presented a paper on the "Surface Geology of

Alaska." He described the formation of the *tundra* and remarked the absence of residual clays, and other evidences of rock decay, as also the absence of glacial records along the Yukon and Porcupine rivers. No evidences of glaciation exist between the Yukon and the Arctic ocean. From the head waters of the Yukon the movement of glaciers has been northward and southward. Incidentally he made a striking suggestion that the great mossy tundra if inundated would on the dissolution of its ice, leave a thick vegetable deposit comparable with a bed of coal. Discussed by Shaler, Chamberlin, Newberry and Lawson.

State geologist, Edward Orton, read a paper on the "Origin of the rock-pressure of Natural Gas in the Trenton limestone of Ohio and Indiana." He showed that the pressure decreases westward, and adduced convincing facts supporting the theory of hyrostatic origin. The facts show the pressure to be directly proportional to the depression of the oil and gas bearing stratum beneath the level of lake Superior. Adverting to the question of duration of the gas supply, he expressed the positive conviction that it is destined to last but few years. The paper was discussed by I. C. White, Lawson and McGee.

Professor W. B. Clark read a paper "On the Tertiary Deposits of the Cape Fear river region." The post-Cretaceous erosion left an irregular surface over which the older Tertiary deposits were spread. Post-Eocene erosion approximately base-leveled this surface, leaving the early Tertiary sediments preserved in the deeper post-Cretaceous depressions. Upon this surface the Miocene strata were laid down. From this history has resulted an intermingling of Cretaceous and Eocene forms in several places, and even of Cretaceous and Miocene types.

Dr. A. C. Lawson, of Canada, read a "Note on the pre-Palæozoic surface of the Archæan terranes of Canada." He showed that along the northern limit of the palæozoic rocks the surface of the Archæan was, at the time of the deposition of the Cambrian, or earlier formations, to a large extent, as hummocky and worn as it is to-day. Hence the feature known as *roches moutonnés* cannot, as is generally supposed be due to conditions of the glacial epoch, except to a very limited extent. There has been but slight reduction of the Archæan surface since early palæozoic time; but the previous denudation was enormous. Discussed by Dr. Spencer.

Mr. R. G. McConnell, of Canada, described the "Glacial features of parts of the Yukon and Mackenzie basins." Read by J. B. Tyrrell of Canada. The paper embraced notes on the silting up of a southern arm of Great Slave lake, on the hight of erratics along the eastern flanks of the Rocky mountains, on the absence of bowlder-clay from the valleys of the Porcupine and the Yukon, and on the former existence of a great lake at the confluence of these two streams. Discussed by Davis, Russell and Gilbert.

Mr. J. B. Tyrrell read a momoir on "Post-Tertiary deposits of Manitoba and adjoining territories of Canada." The area between the Archæan nucleus in eastern Manitoba and the foot of the Rocky mountains, has had in preglacial times, a very irregular surface. This was planed by the continental glaciers—the irregularities being often filled to great depth with the unstratified till. The till or ground moraine, occupies the surface over large districts, but is covered in many places by stratified sands, silts and gravels deposited in the beds of larger or smaller fresh-water lakes. The author presented evidences of a recurrence of glacial conditions; and gave the positions of a number of lakes in which the subsequent glacial deposits were laid down. Discussed by Chamberlin, Shaler, McGee, Spencer and Tyrrell.

A communication by professor G. F. Wright was read in abstract, in the author's absence, by professor C. H. Hitchcock. It was entitled

"A moraine of Retrocession in Ontario," and it aimed to demonstrate the morainic character of the belt of loose ("Artemisia") gravel extending from Owen sound to Brantford, and thence stretching about midway between lakes Ontario and Simcoe. The paper was briefly discussed by Dr. Spencer.

Mr. W. J. McGee presented a communication on "The southern extension of the Appomattox formation." This term was applied in 1888 to a deposit of orange-colored sands and clays, with occasional intercalations of gravel, developed on and between the rivers of eastern Virginia, and widening southward. The writer had recently traced the formation, as the prevailing surface deposit, through the Carolinas, Georgia, Alabama, and Mississippi. It is a marine or brackish-water deposit, yielding no fossils save fragmentary cones and bits of lignite. Much of the "Orange Sand" of Hilgard belongs here. It rests unconformably on the Grand Gulf strata and the fossiliferous Miocene of the Atlantic coast. It is overlaid by Pleistocene deposits. None of its fossils are characteristic.

Mr. Charles D. Walcott presented a communication on "The value of the term 'Hudson River group' in geologic nomenclature." Comparison of the Hudson River section with that in Lorraine, Jefferson county, N. Y., and the Cincinnati section in southern Ohio, proves that the essential palæontologic features of the Hudson River group, as originally defined, are presented in all. Discussed by president Hall.

A paper was presented by professor H. M. Seely in behalf of himself and president Brainerd, entitled "The Calciferous formation in the Champlain valley." The result of the authors' studies made vast additions to the thickness of the Calciferous, demonstrated the imaginary character of the so-called "Quebec group," and necessitated serious modifications of prevailing views of that portion of Vermont. Discussed by Walcott and Hitchcock.

Closely connected with this was the paper by Mr. R. P. Whitfield on "The Fort Cassin rocks and their fauna," the tendency of which was to afford palæontologic confirmation of the stratigraphic conclusions of the preceding paper.

An abstract of a paper by Mr. R. W. Ells, of Canada, was presented by Mr. Walcott, entitled "The Stratigraphy of the Quebec Group." From this it resulted that this group is by latest determinations, entirely eliminated from the science of geology.

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"A moraine of Retrocession in Ontario," and it aimed to demonstrate the morainic character of the belt of loose ("Artemisia") gravel extending from Owen sound to Brantford, and thence stretching about midway between lakes Ontario and Simcoe. The paper was briefly discussed by Dr. Spencer.

Mr. W. J. McGee presented a communication on "The southern extension of the Appomattox formation." This term was applied in 1888 to a deposit of orange-colored sands and clays, with occasional intercalations of gravel, developed on and between the rivers of eastern Virginia, and widening southward. The writer had recently traced the formation, as the prevailing surface deposit, through the Carolinas, Georgia, Alabama, and Mississippi. It is a marine or brackish-water deposit, yielding no fossils save fragmentary cones and bits of lignite. Much of the "Orange Sand" of Hilgard belongs here. It rests unconformably on the Grand Gulf strata and the fossiliferous Miocene of the Atlantic coast. It is overlaid by Pleistocene deposits. None of its fossils are characteristic.

Mr. Charles D. Walcott presented a communication on "The value of the term 'Hudson River group' in geologic nomenclature." Comparison of the Hudson River section with that in Lorraine, Jefferson county, N. Y., and the Cincinnati section in southern Ohio, proves that the essential palæontologic features of the Hudson River group, as originally defined, are presented in all. Discussed by president Hall.

A paper was presented by professor H. M. Seely in behalf of himself and president Brainerd, entitled "The Calciferous formation in the Champlain valley." The result of the authors' studies made vast additions to the thickness of the Calciferous, demonstrated the imaginary character of the so-called "Quebec group," and necessitated serious modifications of prevailing views of that portion of Vermont. Discussed by Walcott and Hitchcock.

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This was a mere abstract, the purport of which was to show that structural features, even those of generic importance, proceed from incipiency, along different affiliated lines to states of full development. The facts tended to show first, the prevalence of variability among the forms of the extinct world, and second, to demonstrate such interrelationships as imply a genetic evolution.

The last paper read was by Mr. F. J. H. Merrill, "On the metamorphic rocks of southeastern New York."

The following papers, on suggestion of their authors, were read by title:

On Glacial Phenomena in Canada. By Robert Bell, Canada.

The structure and origin of glacial sand plains. By Wm. M. Davis, Cambridge.

On certain peculiar structural features in the foot hill region of the Rocky mountains near Denver, Colorado. By Geo. H. Eldridge, Washington.

On the relation between the mineral composition and the geological occurence of the igneous rocks at Electric Peak and Sepulchre mountain, Yellowstone National Park. By Jos. P. Iddings, Washington.

The crystalline schists of the Black Hills, Dakota. By C. R. Van Hise, Madison, Wisconsin.

On the intrusive origin of the Triassic traps of New Jersey; with special reference to the Watchung mountains. By Frank L. Nason, New Brunswick, N. J.

The geology of the Crazy mountains, Montana. By J. E. Wolff, Cambridge.

On some ancient shore-lines and their history. By F. J. H. Merrill, New York.

Geology of the Boston basin. By W. O. Crosby.

On the collection and preservation of geological photographs by the American Geological Society, and the facilitation of their exchange among its members. By J. F. Kemp, Ithaca, N. Y.

Experiments with cave air for cooling and ventilating rooms. By M. H. Crump, Bowling Green, Ky.

On some porphyries of the Plain of Mexico. By Persifor Frazer, Philadelphia.

On the Horned Dinosauria of the Laramie. By E. D. Cope, Philadelphia.

On pot-holes north of lake Superior unconnected with existing streams. By Peter McKellar, Fort William, Ontario.

The total number of memoirs presented was 43. Of these 28 were read either in full or in abstract. With a view to completing the business, a meeting was held on Friday evening, and the last meeting was prolonged from half-past four to six Saturday evening. The wealth of communications was an embarrassment to the Council. It had been determined to allow full discussion on each and reporters were on hand to record the discussions. The plan was impossible of complete execution, for two reasons: Many of the papers greatly overran the estimates of time made by their authors; and not a few were handed in too late to be announced among the abstracts published. Three days were therefore too short a time. Very many of the later memoirs could only be read in abstract, and many others were only read by title. It is expected, however, that all will appear in the BULLETIN. On future occasions it will perhaps be necessary to meet in two sections, or to prolong the session so as to include the Sunday between Christmas and New Year's day.

It is evident that the success of the Society is greater than could have been anticipated. The scientific contributions have not only been numerous, but the subject matter has generally been weighty. Several of the memoirs mark positive and considerable advances in our knowledge of the geology of North America—from the gulf of Mexico to the Arctic ocean. In the work of the Society the Canadian geologists appear to be hearty and unrestrained participants, and this sympathatic relation, it is to be hoped, affords as great satisfaction to them as to the geologists on the south of the international boundary.

The work of printing the BULLETIN is commenced, with W. F. McGee of Washington, as provisional editor.

THE TWO REGULAR MEETINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY on the evenings of Jan. 1st and 15th were occupied in a general discussion of the climatic conditions of the glacial period, by Prof. F. W. Putnam, G. F. Wright, W. O. Crosby, N. S. Shaler and W. M.

Davis, and Messrs. T. T. Bouvé. Warren Upham, Frank Leverett, and others.

In opening the discussion Mr. Upham outlined the geologic proofs of the former existence, within the Quaternary era, of ice-sheets on the northern half of North America and on northwestern Europe, as shown by transportation of drift and the formation of terminal moraines. The maximum thickness of the ice-sheet of the northeast part of this continent was about two miles, according to Dana, and in British Columbia Dr. G. M. Dawson's observations show that country to have been covered by an ice-sheet whose central portion was a mile thick; but the Rocky mountains had only local glaciers, which probably became confluent with the ice-sheets on each side. Toward the northwest the extent of the ice has been defined by the explorations of Russell and McConnell, who find that southern Alaska and the whole course of the MacKenzie bear marks of glaciation, while these are absent along the Yukon excepting near its sources. The climate most favorable for the accumulation of ice in such thickness upon the land would be distinguished from the present by plentiful snowfall during more of the year than now, the surplus above the amount melted in summer being slowly gathered during thousands of years to form the ice-sheets. The departure of the ice and incoming of the present climatic conditions was rapid, as is inferred from the scanty erosion by wave-action and accompanying formation of small beach deposits on the shores of the glacial lake Agassiz, in comparison with the high cliffs eroded in till and the extensive resultant deposits of dune sand on the borders of lake Michigan. The latter have been in process of formation during the whole post-glacial epoch, but its duration, as measured by the recession of Niagara and St. Anthony's falls and by the present rate of the drifting of sand along the lake shore at Chicago, seems to have been not more than 7,000 to 10,000 years. Lake Agassiz, caused by the barrier of the receding ice-sheet, could not have existed so long as this; and therefore the glacial retreat along the Red river valley and by lake Winnipeg to Hudson bay is known to have been geologically sudden. It was, however, attended by the accumulation of numerous morainic belts which denote halts or stages of some re-advance, interrupting the general recession of the ice.

Professor Wright spoke of the Quaternary lava outflows of California, Oregon, Washington and Idaho, one of the lava sheets being penetrated in the upper part of the section overlying the Nampa image; and he inquired whether the volcanic action may have been one of the causes of the amelioration of climate at the end of the ice age.

Professor Putnam referred to the traces of man's presence at the time of both the later and the earlier drift deposits of this country, and the contemporaneous existence of the mammoth and mastodon during the glacial period in the region south of the ice-sheet and their return northward when temperate conditions were restored.

Mr. Leverett stated that the forest bed between deposits of till in Indiana and Illinois proves an interglacial epoch between the maximum extension of the ice-sheet in the Mississippi basin and its incursion when the moraines of that area were formed, the intervening recessions of the ice being to a distance at least two-hundred miles north of the outer moraine. The climatic conditions of the period are thus known to have swayed from severity to mildness repeatedly.

Professor Crosby gave some results of his recent investigations as to the state of mechanical division of the fine portions of the till and its comparatively small ingredient of true clay. His inference is that the proportion of the drift supplied from preglacial rock-decay is much less than that derived from the bed-rocks by glacial erosion; and that the decomposition of the rocks there had been less profound than in the southern states, where a climate both humid and warm acts more efficiently, as pointed out by Russell, to extend this change to considerable depths.

Professor Shaler affirmed his belief that no lowering of the mean temperature is needed to cause the beginning of ice accumulations, which he thinks would result from increase in the evaporation of moisture from the ocean and its transfer by storms spreading over the land. In any attempt to describe the glacial climate, account should be taken of the fact that the ice-sheet advanced, apparently by a forced march, to latitudes far south of the normal snow-plane. Though the ice pushed across the Ohio river at Cincinnati, no trace of local glaciers can be found on the mountains of North Carolina only about two-hundred miles distant to the south; yet they rise more than 5,000 feet higher, and would be mainly above the plane of perpetual show, provided this was represented by the ice-sheet. The final melting of the ice was greatly accelerated, according to professor Shaler, by depression of the land below its present level and the breaking up of the ice-sheet into bergs.

He regards the great conglomerate formations of earlier geologic eras, notably the Carboniferous and Permian, as drift deposits, proving the general prevalence in so remote times of climatic conditions favoring glaciation. To this Mr. Bouvé objected, ascribing the origin of conglomerates to wave action on sea shores and cliffs, often working over rock material which had become separated as boulders by subaerial disintegration.

Professor Davis considered the action of the great cyclonic storms, producing snow in the upper cloud strata, which in falling beneath the thermal plane of 32° Fahrenheit becomes rain. He thinks that to start a glacial epoch refirigeration of the portion of the year when the precipitation now is rain would be necessary, keeping it generally during more months in the form of snow until it reaches the ground. Dr. Croll's theory seems inadequate to account for such climatic changes, and the restriction of large glaciated areas to the parts of the globe adjacent to the North Atlantic ocean suggests that the causes of ice accumulation were terrestrial instead of cosmic. But no satisfactory explanation of the origin of the glacial climate is yet found. Serious objections appear against the view recently urged by Upham with some modification from the opinions long before advanced by Lyell and Dana, that the glaciated areas became covered by snow and ice because of their being greatly uplifted for a geological short time as continental plateaus, giving cool climate throughout the year; and the suggestion of Chamberlin that the position of the earth's axis may have so changed as to bring these areas within the Arctic circle, is perhaps not less difficult for our acceptance.

Mr. A. S. Tiffany, of Davenport, Iowa, sends the following record of a deep well recently drilled at Dixon, Illinois. The well has a flow of 400 gallons of water per minute. Drift, 150 feet; Yellow magnesian limestone, 40 feet; White sandstone, 410 feet; Red argillaceous shale, 50 feet; Red arenaceous shale, 25 feet; Ash colored shale, 225 feet; White sandstone, 135 feet; Drab colored magnesian limestone, 165 feet; Dark gray sand, 100 feet; Light gray sand, 150 feet; White sand, 300 feet. Total depth, 1750 feet.

According to Prof. J. E. Todd a deep well is being bored at Le Mars, Iowa, in pursuit of oil. The record of the boring has been neglected, the operators having no faith in "geological theories," but full confidence in the "dictum of the drill."

Samples sent by Prof. Todd from a depth of 1400 feet are of a normal gray granite, and are said to fairly illustrate the rock below 1060 feet. The red quartzyte of the region seems to have been struck at about 900 feet, but was not firmly consolidated. The drill is making good progress daily in eager pursuit of the coveted oil, regardless of the fact that never was oil found in strata within ten thousand feet above the rock in which it is now at work, and at no place below it.

THE GEORGIA LEGISLATURE HAS MADE APPROPRIATIONS for a geological survey, under Prof. J. W. Spencer, of Athens. Work will begin in the summer. There will be two full assistants in the field.

PROF. ROBT. T. HILL HAS RESIGNED the position of assistant professor of geology in the University of Texas.

PROF. THEO. B. COMSTOCK HAS RESIGNED HIS POSITION at the University of Illinois, and has been appointed by state geologist Dumble, an assistant on the Texas survey, having specially in charge the region of central Texas, embracing strata that are pre-Carboniferous, and including the supposed Archean of that state. Prof. Comstock has been in the field from June to December and has made a very interesting lot of observations, illustrated by ample collections.

A MEETING OF THE AMERICAN COMMITTEE of the International Congress of Geologists was held in the Park Avenue hotel, New York city, on the evening of December 26, 1889, at 8 p. m. Prof James Hall in the chair. Present, James Hall, T. Sterry Hunt, C. H. Hitchcock, E. D. Cope, H. S. Williams, J. J. Stevenson, E. A. Smith, and Persifor Frazer.

A letter to Director Hauchecorne relating to the distribution of the geological map of Europe to the American subscribers was adopted and signed by those present.

Prof. Wm. B. Scott, Mr. C. D. Walcott, and Dr. Robt. Bell were elected members of the committee to take the places respectively of Prof. G. H. Cook (deceased); Maj. J. W. Powell (resigned); and Sir J. William Dawson (resigned).

Dr. Persifor Frazer resigned the office of reporter of the Archean and Prof. C. H. Hitchcock was elected to that office. Mr. Walcott was elected a member of the sub-committee on the Lower-Paleozoic, and Dr. Robt. Bell of the sub-committees on the Archean and the Quaternary, and reporter on the latter. Prof. Wm. B. Scott was elected a member of the sub-committee on the Mesozoic and Cenozoic, and reporter for the former.

Prof. H. S. Williams and J. J. Stevenson resigned as reporters respectively of the Devonic and the Carbonic, and Dr. J. S. Newberry was elected in place of both of them reporter on the Upper Paleozoic.

Prof. W. B. Clark, Johns Hopkins University, was elected an associate member of the sub-committee on the Cenozoic.

Prof. C. H. Hitchcock was elected treasurer of the American Committee, vice Prof. H. S. Williams resigned.

IT IS NOT GENERALLY KNOWN THAT THE LARGEST GOLD MINE in the world is in Alaska. It is lighted throughout by electricity and worked day and night. An offer of sixteen millions of dollars for this mine has been refused.

DURING THE PAST YEAR over 7,000,000 gross tons of iron ore were mined in the lake Superior region. This is a gain of over two million tons over last year, and a corresponding increase in the output is expected for the year to come. The largest production from any single mine was from the Norrie in Wisconsin, and the second largest from the Minnesota mine at Tower, Minn. The combined production of these two mines was considerably over a million tons.

THE FOLLOWING GENTLEMEN HAVE BEEN APPOINTED by the President as commissioners to test and examine the weight and fineness of the coins reserved at the several mints during the calendar year 1889: John P. Jones, United States Senate; E. H. Conger, House of Representatives; H. L. Dodge, San Francisco; William A. Sackett, Saratoga Springs, N. Y.; William Lilly, Mauch Chunk, Pa.; Prof. William W. Folwell, University of Minnesota; Francis A. Walker, president of the Massachusets Institute of Technology; Daniel W. Fisher, president of Hanover College, Hanover, Ind.; Austin Blair, Jackson, Mich., Byron Reed, Omaha; Thomas Price, San Francisco; John Jay Knox, New York; W. D. Wheeler, Montana; Prof. George F. Barker, University of Pennsylvania; Prof. T. C. Mendenhall, Washington; Eliot C. Jewett, St. Louis.

THE PRODUCTION OF GOLD AND SILVER IN 1889 was distributed as follows among the states and territories west of the Missouri river, according to Mr. J. Valentine, general manager of Wells, Fargo & Company, viz: California, $12,842,757; Nevada, $11,908,961; Oregon, $785,361; Washington, $217,000; Alaska, $845,000; Idaho, $17,344,600; Montana, $31,726,923; Utah, $9,830,013; Colorado, $28,074,888; New Mexico, $3,937,677; Arizona, $5,803,027; Dakota, $3,407,177; West coast of Mexico, (by steamer), $512,288; British Columbia, $442,164; Total, $127,677,836.

The separate production of each is as follows; Gold, (25.83), $32,974,643; Silver (51.15), $65,316,107; Copper (11.59), $14,793,763; Lead (11.43), $14,593,323.

The commercial value at which the several metals named herein have been estimated, is: Silver, 94 cents per ounce, Copper, 10 cents per pound, and Lead, $3.80 per hundred pounds.

For the year 1889 the export of gold from the United States exceeded the import by $49,661,101.

RUSTLESS IRON A REALITY.—Says a Pittsburg paper of recent date: The rustless process, which has been until recently an experiment, has now demonstrated that great economy can be used, not only in iron pipes, but in every article where iron is used. In the past year over 2,000,000 kettles have been subjected to this process in Pittsburgh. The method is very peculiar. After the article is made it is put into a furnace about 3½ feet high, 15 feet long, and 8 feet broad. The furnace is made in an oval shape, air tight. After the iron has been in the furnace for two hours, and it has attained almost a white heat, the air that comes through the refrigerators and air valves is shut securely off, and the furnace is made air-tight. After the air has been shut off the superheater, which is located in the combustion chamber at the rear of the furnace, and at right angles from the air-valves, is opened, and the furnace is filled with steam and kept in this condition for eight hours. At short intervals a small valve is opened, so as to allow an exodus of steam in the furnace. When the articles have been ten hours in the furnace there has been accomplished the formation of magnetic oxide upon the iron surface. They are then put into an acid well, which is the last treatment.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—This society has a total membership of 1335. The total receipts of the treasury for 1889, including a balance on hand Jan. 1, 1889, reached $39,799.91. The expenses for the same year were $28,875.46, leaving a balance on hand Jan. 1, 1890, of $10,924.45.

CONSUL BURKE, of Bahia, reports the discovery in that province of a mineral which has been called turfa or brazolina, and which furnishes an oil akin to petroleum, a parafine suitable for the manufacture of candles, and a good lubricating oil. It was originally discovered by an English clergyman named Wilson, but a company has recently been formed, which has bought the concession, and is now engaged in the development of the property. Petroleum extracted from it has already been placed on the market, and has been favorably received.

ACCORDING TO THE ENGINEERING AND MINING JOURNAL there is a notable falling off in the production of Pennsylvania petroleum compared with the consumption. During past years there has been an accumulated surplus, which is now being exhausted at the rate of 20,000 or 30,000 barrels per day, that being the excess over production. Prospecting for new oil territory in Pennsylvania is very active, there having been 5,700 wells completed in 1889, against 1,700 in 1888, and 1,800 in 1887. But the probability that there will be any permanent and considerable increase in the supply is slight. In this condition of the petroleum industry it is plain that very shortly we shall reach an oil famine, when the use of the oil in certain cases will be a luxury instead of a necessity. This will be regulated by a curtailment of the demand through increased cost, tending to equalize the supply and demand. There has been a decline in the shipments of American petroleum to Great Britain during the past four years ending 1888, and an increase of Russian petroleum imported into that country. American imports to Great Britain have decreased from 1,367,720 barrels in 1885, to 1,286,148 barrels in 1888. Russian import increased, in the same period, from 70,149 barrels to 549,126 barrels.

THE GAS EXPLORATION AT FREEBORN, MINN., has been abandoned. It was continued, after the first well had penetrated through the Trenton without finding gas, into much deeper strata, contrary to the advice of state geologist Winchell. Then a second well was begun near the former, and that was also carried down to the St. Peter sandstone. Still no certain evidences of gas were found below the depth of 75 feet, whence has issued all the time, in the drift, a small amount of burning gas. Every well that has been drilled within the limits of Minnesota, in search of burning-gas, except the first one at Freeborn, has been done against the advice of the state geologist—about fifteen in number. Not one has produced gas nor petroleum, Yet there be men who will drill even in granite and gabbro rock in search of gas, in confidence that "geological theories" are of no value. One false judgement by a geologist weighs more against geological evidence, in the opinion of the *men who drill*, than a thousand correct ones.

MR. CHAS. A. ASHBURNER, WELL KNOWN AS A PENNSYLVANIA GEOLOGIST, died Dec. 23, 1889, at Pittsburg, Pa., after a short illness. In a future number a suitable sketch of his life and work will be given.

ARTESIAN WELL WATER-POWER.—At Keokuk, Mr. J. C. Hubinger has recently completed two artesian wells, one of 935 feet and the other 1,805 feet deep. The two wells furnish 1,300 gallons per minute. The two wells run two dynamos, for furnishing electric light for the city. The third well is being sunk to increase the power. The Kimball house well at a depth of 735 feet, flows 600 gallons per minute. It is above low water mark in the Mississippi, 40 feet. This gives 192,000 foot pound per minute, nearly six horse power.

It is not at present known how high this water would ascend. We will estimate thirty feet, and substract seven feet per average on account of the rise of water in the river, which gives an average fall of 63 feet. This year 302,400 foot pounds per minute, more than a nine horse power, without coal, engineer or fireman. When the St. Peter's sand rock is perforated one hundred feet, which will be when the well has attained a depth of about 1,050 feet, the flow will be largely augumented and will attain an altitude in a stand pipe of nearly 100 feet. The expense of such a well will not much exceed $2,200.

Thus, it may be seen, that we have a water power beneath our feet vastly cheaper than steam and cheaper than water power from the river can be made available.—*A. S. Tiffany*, in the *Davenport Tribune*.

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ON THE DIKES NEAR KENNEBUNKPORT, MAINE.

By J. F. KEMP, Ithaca, N. Y.

The southern coast of Maine is very generally seamed with dikes. Localities extending quite from the western to the eastern boundaries of the state are cited in Prof. Hitchcock's reports for 1861 and 1862. Only at Thomaston, however, which is about the middle of the state's sea coast, and at Bald Cliff, which is in the extreme southwest, do the dikes receive more than passing mention, and in these places scarcely more than a paragraph. Dikes belonging to the same general series are known in New Hampshire in the neighborhood of Portsmouth, and are briefly referred to in the New Hampshire reports. But here, also, beyond the simple mention of their existence, little is said. This is not surprising, for without the use of the microscope little can be said of these dense black rocks, and at the date of the reports the use of the microscope in geological work was not general.

In Massachusetts the eruptive rocks of the coast have received more attention,and, as dikes similar to those referred to above are known sometimes of great size, we have much more detailed descriptions of them. Prof. W. O. Crosby mentions them in his Geology of Eastern Massachusetts: Prof. Wadsworth has published some microscopical studies of n the Proc. of the Boston Society of Natural History.

and Dr. Hobbs has gone into considerable detail in his recently published paper in the Harvard bulletins on the Great Somerville Dike.

It will be seen from this that there is considerable material for petrographical work in this region, and some interesting geological phenomena which have, as yet, scarcely been touched. In the present contribution it is the writer's purpose to show by the aid of the accompanying map, how abundant the dykes are in one limited area which he has worked up, and to give an idea of the detailed geology of a region by no means too well known.[1]

Kennebunkport is some twenty or twenty-five miles beyond the New Hampshire line. The coast is formed by bold, rocky headlands and cliffs, between which are found long stretches of white sandy beach. At the water's edge most excellent exposures are afforded, running sometimes a short distance back before the rocks are covered by vegetation. They consist of very finely stratified quartzytes, slates and jaspery layers, with vertical dip and a somewhat variable strike, which is indicated on the map. At Kennebunkport it varies from N. 40 E. to N. 40 W., while fifteen miles south on the coast, at Bald Cliff, it is N. 75 to 80 E. The strata belong to the Merrimack group of the New Hampshire survey and are there assigned a position at the close of the Archean. These strata are undoubtedly old sedimentary beds, whose composition has varied from sandstones to shales, as we almost invariably find them in the undisturbed sedimentary series, as for instance, the Devonian above Ithaca. The sandstone layers are now changed to compact quartzytes, while the shales are of pronounced slaty structure. Sometimes the slaty cleavage runs obliquely across the bed, even when but a few inches thick and between two quartzyte layers, showing that the pressure causing it has not been quite normal to the bedding planes.

Very generally above Kennebunkport, great irregular masses or bosses of granite are found in these metamorphic rocks. They are quite coarsely crystalline, have no regularity of form and are often of considerable size. The granite also runs off at times into narrow dikes which extend considerable

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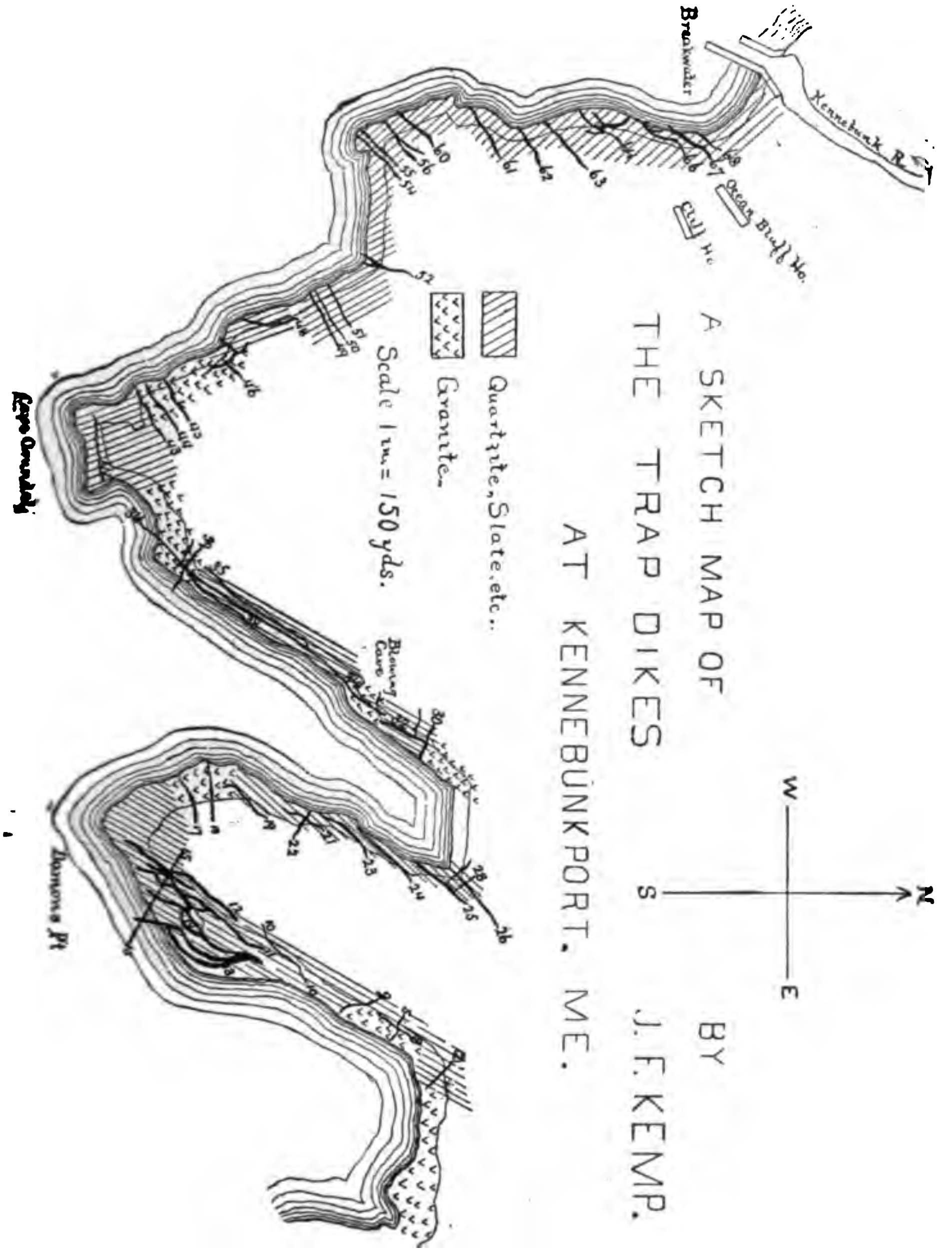
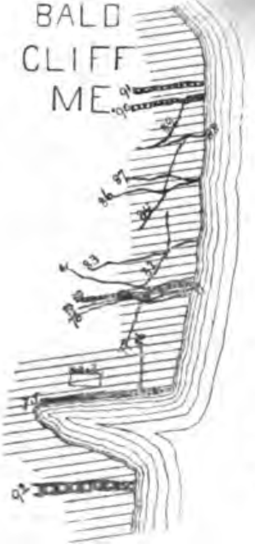
[1] The legend of the accompanying map does not allow for the reduction of the original in the engraving. It should read ½ in.=150 yds.


A SKETCH MAP OF
THE TRAP DIKES
AT KENNEBUNKPORT, ME.
BY
J. F. KEMP.
Quartzite, Slate, etc..
Granite.
Scale 1 in. = 150 yds.
N
S
W
E
Kennebunk R.
Breakwater
Ocean Bluff Ho.
Club Ho.
Cape Arundel
Blowing Cave
Damon's Pt.

distances. They are nevertheless well crystallized, and seem to exhibit no amorphous structure, indicative of quick solidification, whatsoever. Prof. Hitchcock refers the coast granite of Maine, when found in such situations as this, to an aqueo-igneous fusion of the sedimentary rocks, and it is, considering their surroundings, a very natural explanation. The narrow dikes seem to indicate in instances a very complete fluidity and some injective action. No one could be severely criticized, perhaps, for considering the parent masses also injected, but as the question is largely speculative, it is not one on which demonstrated truth can be expected. Judged by the latest petrographic light, we must consider the granite to have cooled and crystallized slowly, doubtless under great pressure, it being so perfectly holo-crystalline.



Subsequently to the granite the so-called trap dykes were intruded. They cut both the stratified rocks and the granite indifferently, and sometimes cross one another. From these inersections Prof. Hitchcock has traced at Bald Cliff three different intrusions in time, to quote his words,—"The eldest is a porphyritic trap developed in very large dykes in the slates and running N. 55 E. The second series of dikes cut across the porphyritic dikes, and have frequently greatly displaced them. These run northeasterly and are the most common of all the dikes in Maine. The third series is a brown scoriaceous trap cutting across the common trap." Parallelism of direction is cited as an indication of unity of age, equally with similar mineral composition. While this last may be true for Bald Cliff, it hardly holds at Kennebunkport, for while in the case of the dikes in the stratified rocks there is some parallelism, when in the granite they run in all directions. Also in the former case they branch, fork, and anastomose in great variety. My own observations at Blad Cliff confirm Prof. Hitchcock's three epochs and kinds of intrusion perfectly. At

Kennebunkport the evidence of three epochs from the intersection of the dikes is less abundant. The porphyritic type,--Prof. Hitchcock's first class,—is represented, but a case of faulting by the latter ones I can not cite. The second series are the ones most developed, and even here their general northeasterly direction can be remarked on the map. The third brown scoriaceous variety is also often seen and evidently faults the others.

At Kennebunkport the dikes are not of great width, averaging generally five feet and less. Only one or two run as high as twenty. But their persistence for their small width is remarkable. One may be seen on the map to start from the point called Spouting Cave, and run along the east side of cape Arundel nearly half a mile, yet nowhere above eight or ten feet in width, and frequently less. It then runs under the water, and may go farther. Dikes not more than a foot wide frequently run several hundred feet, as on the eastern side of Damon's point, and small stringers but a few inches run forty or fifty feet and pinch out very gradually to a feather edge. It seems remarkable that they were able to preserve their liquidity for any such distance, but it is easily noticeable macroscopically, that where such is the case the dike is very compact, well nigh glassy in structure.

Sometimes a tendency is exhibited to separate into rude basaltic columns across the dike, but in general they are quite solid masses. Rarely spheroidal weathering is seen, chiefly in the dikes of the third epoch. They then break up into rounded masses, six inches and less in diameter, but always in the middle part. In the larger dikes there are frequently to be seen smaller dike-like masses running through them, as if the yet molten interior had oozed through cracks in the outer hardened crust, as is frequently to be seen in our modern lava flows from active volcanoes.

The rocks will be treated in reference to their microscopic structure in the order of their formation. The granites are the oldest. The rock occurs both as bosses or knobs and as dikes, which are undoubtedly off-shoots from the larger bosses, even when the connection is not visible. On the map, dikes 2, 9, 16 and 28 are granite. They are about one or two feet wide, and often extend two or three hundred feet. They consist of quartz, microcline, orthoclase, plagioclase, and biotite, but the

thei elves. An occasional apatite inclusion
only additional component that catches the ey
glassy material whatever. The average crystal
to five m.m. But with them are to be seen lar
orthoclase, as much as five c. m. in length by o
—which give the dike somewhat the aspect
porphyry. The phenomena cited above agre
tials with those mentioned by Rosenbusch in des
dikes, (Mikros. Phys. vol. I. p. 279) and from th
may see that similar phenomena are known
Ireland, and in the tin district of Saxony.

The granite dikes and the bosses not infreq
in their mass fragments of the country rock. T
rather thin-bedded mica schist and quartzite, a
fragments give us one of the surest indications
character of the granite. The walls on the c
dikes and the included masses are very gener
talline aggregates of biotite and quartz. The
only 1-20 mm. in breadth, by 1-5 mm. long, ar
parallel to the contact, as if a great pressure h
to take such a position. They seem to corre
commonest contact minerals present on the
Cortlandt series,[2] on the east side of the Hudso
the writer's possession from the contact schist
on the west side, are very similar.

On the eastern side of cape Arundel, near d
the schists have been much shattered and fissu
have been subsequently filled with vein matte
resembles a granite. It consists of quartz, ort
muscovite, and tourmaline. The resemblanc

striking, but a careful search failed to discover any cassiterite. These veins were undoubtedly occasioned by the active circulation due to the intrusion of the granite, accompanied perhaps by boracic and fluoric fumerole action.

The remaining dikes are in most cases forms of the olivine-diabase type, but of a somewhat varying structure, owing in part at least to their varying width. They are most frequently holocrystalline, yet porphyritic ones are also present, and the ground mass is somewhat glassy. I have selected as the type, the holocrystalline form, and will consider the others as structural deviations from it. This is shown in dikes 11, 13, 15, 17, 19, 21, 22, 23, 24, 29, 30, 34, 35, 48, 51, 55, 56, 60, 61, 63, 67, 75, 76, 77, 78, 80, 81, 82, 83, 86, 87, 89, 91. Of these 48 and 56 are the best. They consist of augite, plagioclase, olivine, and magnetite as essentials. With these is found very often (dikes 11, 22, 34, 48, 55, 56, 60, 63, 81) brown basaltic hornblende, both as an undoubted idiomorphic component, and as an equally indubitable paramorph from the augite. Biotite was noted in but three, and then in a very subordinate capacity. Dike 91 alone contains any great amount. Pyrite also is present.

The augite is of the usual rose tint, and resembles very closely the augite of certain New Jersey triassic diabases and the Campton Falls olivine diabase of Hawes. No pleochroism could be detected. It shows the usual cleavages, but often in addition other partings parallel with the pinacoids. It occurs in two generations: the older and rather exceptional shows the eight-sided cross-section of ∞P, $\infty P\acute{\infty}$ and $\infty P\bar{\infty}$ and is 1-2 mm. across; the latter is most frequently seen, and appears as irregular masses, about 0.2-0.3 X 0. 5 m m.. forming the largest part of the rock. Twinninig is rare, but sometimes is often repeated on the same crystal. In dike 75 twins were noted parallel with $\infty P\bar{\infty}$ and twenty differently oriented layers were counted within 0.5 m m. The augite frequently alters to a feebly pleochroic chlorite.

The plagioclase is in the usual lath-shaped crystals of quite irregular outline, being in the more coarsely crystalline specimens stocky and broad,—in the more finely crystalline, in very slender rods. It falls an easy prey to alteration, which has often proceeded so far as to reduce the feldspar to a kaolinized mass. Sometimes a dark green nucleus appears with-

tions. As a matter of course, it always shows
nings of alteration to serpentine, and more often
serpentine alone remains. This alteration prod
times the interference crosses of radial aggreg
The last stage leaves a core of calcite surrounded
ing rim of serpentine. The olivine preceded all
cept the magnetite in formation. The magnetite
often showing octahedral outlines, and at times
iferous. The most interesting of all is the hor
noted above. it appears in not a few of the dikes
times idiomorphic, exhibiting ∞P and $\infty P\bar{\infty}$ wit
acteristic pleochroism usual to the brown bas
When this is present in abundance the dike app
typical camptonites very closely. Dike 22 could
tinguished in the slides from Hawes' olivine-
Campton Falls. Again the hornblende surroun
or is such a close part of it that a paramorphic o
augite is an irresistible conclusion. The wid
tion of microscopic study has shown this to be
mon phenomenon, and in American dikes has it
those mentioned below.[1]

The porphyritic types of structure occur un
differing relations. The exceedingly narrow
those that taper out to an edge in the country roc
have oozed into cracks in larger and partly cc
ways show a porphyritic structure, which is easi
to their quick cooling. But strangely enough,
dike of all (92) and others of no inconsider
likewise porphyritic. The greater number mus
belonging to the melaphyre type (Nos. 10, 12, 32

88), while in a few the olivine seems to fail, and their characters are more of the augite porphyrites (Nos. 33, 90, 92). In one the basaltic hornblende is the most notable of all the constituents, and of itself the dike would be a hornblende porphyrite (No. 25), such as in the writer's estimation would place it in the series of typical camptonites. This is the most interesting, as showing here such a close parallel to the original camptonites of Hawes, at Livermore Falls, N. H. (Amer. Journ. Feb. 1879). There, as well as here, diabase and olivine diabase occur with the dioritic rock in parallel dikes, but while hornblende is there the rule, here it is the exception. Rosenbusch, in a review of Hawes' paper (Mikros. Phys. B. I. p. 333) groups all of the Campton dikes under the one name Camptonite, considering the variations in mineral composition not sufficient to separate them sharply. While that is a just and fair view, the abundance of the small basaltic hornblende crystals in the Campton dykes, and in the various others which have come to light since,[1] should make *its* presence the chief diagnostic feature of a camptonite. The writer would not consider these normal olivine diabases of Kennebunkport as true camptonites, but rather, that from some exceptional circumstances of composition or cooling, one or two of the dikes had crystallized as such and several had approximated it.

The idiomorphic minerals of these porphyrites do not essentially differ from those described in the holocrystalline examples. The ground mass in the very narrow forms is glassy but not very transparent, on account of multitudes of inclusions. In the broader ones, and especially 92, the base is microcrystalline, and mostly made up of very minute plagioclase rods. Such rods appear in all these latter dikes, often distributed through a relatively abundant ground-mass. The glassy structure is sometimes developed in the edges of dikes whose centre and largest part is holocrystalline. A slide from dike 27 exhibits the wall as a mass of quartz and pyrite,—then a porphyritic strip 5 mm. wide,–then a very finely crystalline interior. The borders are in each case sharply marked. This may be explained by the partial fusion and involution of the wall, and by quick cooling, but when dikes one and two feet wide are holocryslalline, and another, forty feet, is porphyritic some other structural factor must have entered. In the porphyrites, the olivine, when present, is the most striking mineral. Its size, even in the very narrow glassy examples, is hardly les than in the large dikes. Its crystallization must have occurred at a relatively early period,—and itself was well developed while all the others except magnetite were still undifferentiated in the magma.

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[1] B. J. Harrington, Geol. Surv. Canada.—1877–78, p. 439.
J. F. Kemp, Amer. Jour. Apr. 1888. Amer. Naturalist, Aug. 1888; the same, and V. F. Marsters, AMER. GEOL. Aug. 1889.

On account of lack of opportunities and time, the chemical examination of these dikes has not kept pace with the microscopic, much to the writer's regret. One analysis of the large augite-prophyrite (No. 92.) has been kindly made by Mr. H. A. Flint in the laboratories of the University, and is here appended:

Loss on ignition	0.69	0.68
SiO_2	51.93	51.72
Al_2O_3	18.13	27.15
Fe_2O_3	8.92	
CaO	9.82	9.95
MgO	5.30	5.31
Na_2O	4.34	4.35
K_2O	1.42	1.46

It would appear from this that the feldspar is probably an oligoclase. The rock is certainly more acidic than the general run of the dikes.

The writer was much assisted while in the field by Mr. Harris Kennedy, of Roxbury, Mass., and after he had been compelled to leave the region, Mr. Kennedy continued the work in some neighboring localities. The dikes are found on cape Porpoise, two miles north of the limits of the map, and at the mouth of York river, eight or ten miles south of Bald Cliff. The olivine-diabase at Lewiston, inland and to the north, the so-called black granite (determined to be olivine-diabase by G. P. Merrill,—10th Census, Rep't on Building Stones, p. 24) at Addison point, away along the eastern coast, and the peridotite at Little Deer Isle, (G. P. Merrill, Amer. Jour. June, 1888.) are other allied rocks which have already been noted in the state.

It appears that the commonest type of dike rock elsewhere noted, is an olivine diabase, or simply a diabase without olivine. Haworth[1] found such in the Archæan of Missouri; Hobbs,[2] the same in Massachusetts; Lawson,[3] in the Provinces north of Minnesota; Herrick[4] and others, at Michipicoten bay; G. F. Richards,[5] in South Carolina; and the writer in certain undescribed specimens from the Adirondacks. It seems as if Archæan dikes especially favored this mineralogical aggregate.

TABULATION OF DIKES.

No. on Map.	*Width.*	*Character.*
2.	2'	Granite.
5.	1'	Not determined.
8.	—	Olivine-diabase.
9.	1'	Granite.
10.	18"	Melaphyre.
11.	10'-15'	Olivine-diabase, Hobbs.
12.	1'- 2'	Melaphyre.
13.	—	Olivine-diabase.
14.	—	Included schist.
15.	4'	Olivine-diabase.
17.	2'- 4'	“ “
18.	18"	Not determined.
19.	4'	Olivine-diabase.
21.	2'	“ “
22.	2'	“ “ Hobbs.
23.	2'	“ “
24.	2'	“ “
25.	3'	Camptonite.
26.	8'-10'	Olivine-diabase.
28.	—	Granite.
30.	8'	Olivine-diabase.
32.	Narrow.	Melaphyre.
33.	“	Not on map—Augite-porphyrite.
34.	10'-12'	Olivine-diabase, Hobbs.
35.	8'	“ “
38.	5'	Not determined.
39.	4'	“ “
41.	3'	“ “
43.	4'	“ “
44.	10'	“ “
45.	1'	“ “
46.	6'- 8'	“ “
48.	8'-10'	Olivine-diabase, Type-Hobbs.
49.	3'	Not determined.
50.	1'	Melaphyre.
51.	3'	Olivine-diabase.
52.	2 branches. 6' and 20'	Porphyritic. Not determined.
54.	10'	Not determined.
55.	7'-10'	Olivine-diabase, Hobbs.
56.	20'	“ “ Type-Hobbs.
60.	10'-12'	Olivine-diabase, Hobbs.
61.	2'	Olivine-diabase.
62.	6'	Not determined.
63.	6'.	Olivine-diabase, Hobbs.
64.	2'- 4'	Not determined.
66.	1'	Melaphyre.
67.	30'	Olivine-diaba
68.	6'- 8'	Not determi n
75.	12'-15'	Olivine-dia
76.	1'- 3'	“
77.	2'- 3'	“ “
78.	15"	“ “
79.	1'-18'	Melaphyre.
80.	6'	Olivine-diabase.
81	—	“ “ Hobbs.
82.	3'- 4'	“ “
83.	5'	“ “
84.	1"-4'	Melaphyre.
86.	1'- 2'	Olivine-diabase.
87.	2'- 3'	“ “
88.	1'	Melaphyre.
89.	1'	Olivine-diabase.
90.	5'	Augite-porphyrite.
91.	20'	Olivine-diabase.
92.	40'	Augite-porp h

In the case of the Kennebunkport dikes, it is very remarkable that nowhere any very great parent mass shows itself, for we would naturally regard these narrow dikes as simple offshoots from some large body at no great distance, which have

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[1] Haworth, AMER. GEOLOGIST, May, June, 1888.
[2] Hobbs, Bull. Mus. Comp. Zool. Vol. XVI, No. 1.
[3] Lawson, Proc. Can. Inst. Apr. 1888.
[4] Herrick, Tight, and Jones, Bull. Denison Univ. Vol. II p. 119.
[5] Richards idem, Vol. IV, p. 5.

been intruded along lines of weakness, cracks, etc. If they have come from great depths, along so extended a coast line, and of such narrow widths, it is certainly a striking phenomenon. Or if there is a parent mass at no great depth, which, however, has in this same extended area failed in any greater amount to show itself, it is not less striking. It may be that the parent mass, if there is one, is now covered by the sea. The prevailing northeasterly trend of the dikes is parallel to the general axis of folding along the eastern coast, and they may somehow be connected with it. Dr. Hobbs, in speaking of the Somerville dike further south, mentions that it (we may add, and perhaps these to the north) have some connections with the extended intrusions of Triassic diabase, so frequent from Nova Scotia to the Carolinas. The particular time and source of the dikes, however, must with our present knowledge be almost entirely a matter of speculation.

Geological Laboratory, Cornell University.

TRIASSIC TRAPS OF NOVA SCOTIA, WITH NOTES ON OTHER "INTRUSIVES" OF PICTOU AND ANTIGONISH COUNTIES, N. S.

By V. F. Marsters, Ithaca, N. Y.

Of the numerous trap ridges and knobs which occur in Nova Scotia, perhaps the largest and most prominent is that known as the North mountains, on the southeast of the bay of Fundy. This ridge, extending with two or three exceptions in a nearly unbroken line from cape Split on the northern to Briar island on the southern extremity, rests upon Triassic sandstones. It has a length approximating 120 miles and a breadth, from the brow of the mountain to the water's edge, varying from one to five miles. While cape Blomidon attains an altitude of only 400 feet, the extreme hight of the range, which occurs in the section known as Marsters' mountain, is about 450 feet. The southeastern edge of the superimposed trap is quite thin, but it attains a considerable thickness toward the rock-bound coast as shown by the hight of the jagged trappean cliffs along the shore. The dip is about N. 15° W.[1] The outliers occurring in the bay of Fundy and along the coast of Cumberland Co. are Partridge island, Five islands, cape Sharpe, and Haute island. All these, like the main deposit, overlie Triassic sandstone. The Triassic sandstone also dips in the same direction and at the same angle. Hence it results that the abrupt termination of the southeastern edge of the trappean area, gives a monoclinal form to the valley on the south of the mountain. The depth of the valley has undoubtedly been increased, by the erosion of the sandstones, a fact of which there is abundant evidence. This agent was probably the chief means in reducing also the thickness of the trap on the brow of the mountain. The sandstone area, which is severed into two distinct parts by the interruption of Minas basin and Avon river, extends on the southwest through Kings, Annapolis and Digby counties. In the eastern part of Horton township it overlies highly inclined and partially metamorphosed slates and shales of Carboniferous age. The Carboniferous series is admirably exposed on the Avon river and is generally known as the "Horton Bluff" series.[2] The eastern part of the Triassic area can be traced in irregular patches along the shores of Minas basin and Cobequid bay as far east as Onslow and Truro, where it was observed to rest unconformably upon limestones and shales exhibited in the hills of Osnlow and along North river. It attains its greatest width (18 miles) in Kings county, and gradually decreases towards each extremity.

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[1] See Acadian Geology.

The general geological features of this trappean ridge suggest that it was formed by a true submarine volcanic eruption. This conclusion is strengthened by the fact that the formation is composed of two definite layers, the lower stratum being composed of scoriæ and volcanic ashes, the upper stratum of much denser, firmer and often columnar trap, a phenomenon which is known to exist in almost all volcanic regions.

In comparing this deposit with similar ones in the United States, I notice a striking resemblance between them. In one or two particulars, however, some different features occur which are worthy of note. The Triassic traps of the eastern states have received considerable attention from Prof. W. M. Davis, who considers all trappean deposits whose upper stratum presents an amygdaloidal or vesicular structure as evidence of an "overflow," which has cooled without subjection to overlying pressure. Hence wherever the deposit has attained a considerable thickness, the lower part would necessarily become more compact and firm. Such conditions suggesting an "overflow" are reversed at cape Blomidon. The scoriaceous vesicular material forms the lower stratum while the more dense variety is superimposed. On the other hand if the ridge was a typical "intrusive" its metamorphosing effect along the line of contact with the underlying sandstones would be more marked than was observed by the writer. These apparently reversed features, however, may prove on further examination to be only a local variation.

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[2] The "Horton Bluff" series has been well described by Sir Wm. Dawson in his "Acadian Geology," p. 92 and p. 252.

Little substantial evidence can at present be found of a volcanic vent, which, if it ever did exist, was subsequently worn away by the denuding forces of the Drift period. Yet the physical features of the deposit suggest that such may have existed contemporaneously with its formation. There is also at cape Blomidon some local evidence of the formation of its northern extremity by a limited overflow of an immense dyke extending from the vicinity of Amethyst beach, towards cape Split.

This trappean mountain received the attention of geologists as early as 1836 when we find it quite accurately described by Dr. Gesner in his "Geology and Mineralogy of Nova Scotia," and later (1868) much more fully treated by Sir William Dawson in his Acadian Geology.[3]

The more compact columnar trap is light grey in color, of a somewhat gritty texture, and having a specific gravity of 2.93. The lower stratum consisting of volcanic ashes and scoriæ is bronzy reddish-brown in color and full of small cavities in which are found minerals belonging mainly to the Zeolite group. Some of the most common ones occuring in this region are, *analcite*, *chabazite*, *acadialite*, *natrolite*, *stilbite*, *heulandite*, *apophyllite*, *prehnite*, *agate* and *amethyst*. In fact cape Blomidon and its outliers have long been noted for the great variety and beauty of their mineral productions, as well as for the unique character of their scenery. The bold promontory of "Blomidon" as seen from the classic "Hill of Acadia," is a scene not to be easily forgotten even by the most casual observer.

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[3] For a minute and full description of the extent and geological features of this obscure formation the reader is referred to the above works.

So far as the writer is acquainted no microscopic descriptions of the Triassic traps of the North mountains or of any of the intrusive rocks of Nova Scotia have been published. Although I find in the "Canadian Reports of Progress" numerous references to dykes, granitic bosses, and trappean areas, yet seldom more than a very general macroscopic description, and occasionally only the location is given. Hence extended examination of this province would undoubtedly furnish much interesting material for microscopic investigation. The writer therefore hopes that in the near future he may be able to make a closer study not only of the Triassic traps but also of other known eruptive rocks in this region.

The trap, like all those from similar deposits in the United States, is a typical diabase. Under the microscope it proves to be composed chiefly of plagioclase with generally irregular and scattered masses of augite, magnetite, sometimes showing perfect octahedral forms but in the main massive, and a brownish mineral probably resulting from the decomposition of the augite. The plagioclase which presents little evidence of decomposition consists of lath-shaped crystals exhibiting very good crystallographic terminations, They are almost universally twinned but seldom exhibit marked zonal structure. These sections, approaching the zone of the axis of symmetry show a decided fracturing as ifsubjected to great pressure or some mechanical disturbance subsequent to the completion of their crystalline form. It makes up the most prominent component of the rock. Augite exhibits irregular small masses with brightly polarizing centers and muddy, dark-brown peripheries. The brownish product, which is of secondary origin extends along the cracks so universally present in augite, presenting a net-like appearance. Whenever a crystal occurred sufficiently fresh and regular in form for orientation, it proved to be twinned on the orthopinacoid. Magnetite occurs for the greater part in irregular aggregates which may be of secondary origin, but not presenting a titaniferous aspect. The perfect octahedra are undoubtedly primary and were probably the first to form during the cooling of the fused mass. Compared with sections of Triassic traps from New Jersey, kindly loaned me by Prof. J. F. Kemp,[4] I find a marked resemblance both as regards the optical characteristics of the individual minerals and the relative quantities of each component.

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[4] The writer is highly indebted to Prof. J. F. Kemp for many suggestions and references to published matter dealing with similar formations in U. S.

While making a hasty review of the "Report of Progress (1886) of the Canadian Geol. Survey" numerous references to intrusive rocks were noted in an article by Hugh Fletcher Esq. on the geology of the eastern counties of Nova Scotia. During a short visit to my native province I made a hasty trip over parts of Pictou and Antigonish counties, so well described by Mr. Fletcher, with the intention of finding a few of the "intrusives" referred to. Owing to the short time at my disposal I succeeded in finding but two eruptive masses. On Arisaig coast at the mouth of McAra's brook, was found amygdaloidal trap interstratified with lower Carboniferous conglomerates, and at many places breaking through the bedding of the conglomerate in a very irregular and complicated manner. A short distance northeast of this point another trappean mass was found presenting similar conditions. The conglomerate is but slightly altered at the point of contact. So irregular was the mass that it was impossible to obtain any definite information concerning its dip or actual thickness. Whether the ejection of this rock was contemporaneous with that of the numerous Triassic patches to the west, there does not at present appear any evidence; but further examination may prove that such is the case. In its macroscopic characters the rock resembles very closely the vesicular traps of cape Blomidon. Its lower specific gravity, however, (2.748) proves it to be much less basic.

Under the microscope the rock proved to be composed mainly of feldspar, with irregular patches of augite and a whitish mass, a secondary product probably derived from the feldspar. The feldspar which is probably plagioclase, is too much decomposed to show any very decided optical properties. Their typical lath-shaped or rod-like form, however, is fairly well exhibited. The augite is scattered through the rock-mass in small, irregular patches, presenting no crystalline form, but a few cases sufficiently fresh, and presenting cleavage cracks, and optical properties sufficient for orientation. No magnetite was observed in any of the sections from this locality. While the rock is made up of the same mineral constituents as the diabase from "Blomidon" it does not present the same *facies* of the typical diabase as described above.

The second eruptive mass referred to was found high up the west branch of Barney's river. The dike, so far as could be seen in the river bed has attained a width of some fifty or sixty feet. On either bank, however, it presents the appearance of an overflow. The greenish argillaceous slates in which the dike is situated are thought by Mr. Fletcher[5] to be upper Clinton. At the point of contact with the dike the slates were considerably altered but so far as could be observed were not disturbed to any great degree. On account of the dense forest on either side of the stream I was unable to trace it beyond the banks of the picturesque gorge.

A microscopic examination proves the rock to be a feldspar porphyry containing also well developed crystals of augite and magnetite. The phenocrysts of plagioclase which are mainly idiomorphic are considerably altered, but not to such a degree as to obliterate under polarized light their twinning and apparently zonal structure. Much fine dust, probably magnetite, is included in the plagioclase in much larger quantities in the central part than in the periphery of the individual crystal. The augite which is also idiomorphically developed shows occasional corroding effects and nearly complete alteration to a brownish isomorphous product. The average size of the individual is about 2.5 m.m. in length by 2 m.m. in width. In one individual a peculiar instance of twinning apparently on the clino-pinacoid was exhibited, but sufficient data could not be obtained to prove beyond doubt the accuracy of the above statement. In addition to the fine magnetic dust already mentioned there was also shown almost perfect octahedra a few of which were included within the phenocrysts of augite.

At present the writer is unable to connect this dike with any parent eruptive body. He is of the opinion that an extended search will prove that it, together with other numerous eruptive rocks described by Mr. Fletcher, may have some connection with a parent body which was the central point of eruptive and intrusive action.

Geological Laboratory, Cornell University, Dec. 4th, 1889.

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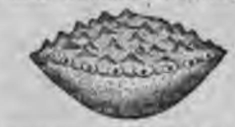
[5] Report of progress 1886. p. 45, P. Canad. Geol. Survey.

BATOCRINUS CALVINI.

Description of a New Species of Burlington Crinoid.

By R. R. Rowley, Curryville, Mo.



Batocrinus calvini. n. sp.

Body depressed, nearly twice as broad as deep; calyx saucer shape; plates rather thick and those in the calyx smooth and without any apparent convexity, while those in the vault are tuberculate; basal plates elongate and without a rim, being merely excavated for the reception of the column. Excavation indicates a comparatively small round column; columnar perforation but little larger than a needle point.

The long upper side of the basals support the first radial plates which are hexagonal, and once and a half as wide as deep. Second radials small, twice as broad as long, quadrangular. Third radials, or primary bifurcating plates, pentagonal, twice as wide as long and but little larger than the second radials, supporting on their upper sloping sides a quadrangular piece on the right and a pentagonal plate on the left. Each of these latter pieces supports a large secondary bifurcating plate, over three times as wide as long and the largest piece in the ray except the first radial. The secondary bifurcating plates support on the left, above, a pentagonal and on the right a hexagonal piece, each of which, in turn, supports an arm-bearing plate.

First interradials large, width and depth about equal, heptagonal and nearly as large as the first radials. Above the first interradial is a much smaller hexagonal piece, about as long as wide. A minute plate lies to the right of the line of division between these interradials.

The first plate of the anal series is quite as large as the first radials and, like them, is hexagonal and rests on the upper side of a basal. A second hexagonal piece, two-thirds as large as the first, rests upon the upper side of the latter. Width and depth about equal as in the first anal plate. Above the second anal piece is a long third piece, heptagonal in outline and nearly twice as long as wide. Four other plates of the anal area rest on the upper and lower lateral edges of the second anal piece and are but little smaller than that plate, being as long as wide and all hexagonal.

Arm openings 18 in number and directed upward,

The calyx meets the vault in a sharp rim. Vault or dome but slightly convex, with plates strongly nodose, almost spiniferous; base of anal tube strong; column and arms unknown; width of body nearly one inch; depth little more than half an inch.

The peculiar depressed shape of the body of this crinoid, its smooth calyx and tuberculate vault plates, sharp rim at the arm bases and the simple excavation for the column,readily distinguish it from any other already noticed Burlington Batocrinus.

Described from two perfect bodies, found at the very base of the Lower Burlington limestone, at Louisiana, Mo.

The specific name is given in honor of Prof. Samuel Calvin of the Iowa State University.

THE TRAINING OF A GEOLOGIST.*

By John C. Branner, Ph. D.

The fitting of a young man for his work in life is worthy of our serious study and consideration, and while much that I may say is equally applicable to men in any calling, I can only undertake to speak of some of the demands that the times are placing upon geologists.

It is to be expected, of course, that there are plenty of persons of intelligence in the world who have no conception whatever of a geologist's duties, those who imagine that geology as a profession can be picked up just as the duties of certain civil offices, or of clerical positions, may be readily learned and performed by any man of ordinary intelligence. Among the applications I have received for employment one man gave as a reason why he should be employed that he was a consistent member of the Presbyterian church; another that he was a graduate of a famous military school; another was interested in geology and had read many books upon the subject, among which he cited some of the vaporings of Ignatius Donnelly; still another used to be acquainted with professor Winchell, and another was in poor health and thought field work would be good for him. At least half of the applicants have asked for employment because they understood ordinary land surveying, and one of them admitted that he had no other qualification than that he was "a good hand to camp out."

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*Presidential address before the Indiana Academy of Sciences, Indianapolis, Dec., 30th, 1889.

The general academic training of a geologist during the first two or three years of his college course is not essentially different from that of any man of culture. I am not disposed to side with those who think that if a man is to be a specialist the sooner he begins his specialty the better. In a general way this proposition is correct, but in making such an admission it must be distinctly understood that all things which tend to broaden a man's scholarship form essential parts of his specialty.

That a man should have a knowledge of history, philosophy, social science, and of literature in general goes without saying. But as bearing directly upon his professional career he should understand, of the languages, at least the Latin, French and German. In mathematics he should have the general instruction required by civil and mining engineers, and should give especial attention to astronomy and geodesy. In chemistry the more thorough his training the better, and beside the usual work required of students of chemistry,in which especial attention should be given to inorganic chemistry, he should be a skilled mineralogist and should be well acquainted with metallurgical processes. In physics the student should give attention to optics, especially as employed in the construction of mathematical instruments; to hydraulics and hydrostatics, to dynamics, and to hypsometry.

I have sometimes thought that to be a good and successful geologist one should first be a good civil engineer and then a good mechanical and mining engineer. This thought has been suggested to me by the fact that among the students I have had to train in geological work those from the engineering courses have, almost without exception, proven themselves by far the best qualified. This is due to the fact that a large part of a field geologist's work consists in tracing out in the field, and the delineation upon maps and cross sections, of structural features. In this work topographic features—the elements of horizontal and vertical distances—have to be so constantly dealt with that unless the student has pretty thorough training as an engineer he will find the work very tedious. I should make it plain, however, in referring to the desirability of a geologist having an engineer's training, that I do not mean to imply that an engineer can always step into geology and make a success of it, for it is only the very young engineer who can or will make the proper use of his technical training. As a rule the man who has been a practicing engineer for a number of years is no longer sufficiently pliable in habits of work and thought to make a successful geologist. In geology various degrees of detail are required. Sometimes our measurements need to be made with a micrometer, at others with a foot rule, while at other times an error of several feet is of no consequence, but a civil engineer who has been accustomed to the degree of accuracy required in railway construction can not always bring himself to use now a less accurate method, and now another of great precision, just as circumstances may require. But whether the student receive the full training of a civil and mining engineer or not, he will need to acquaint himself with practical and theoretical land surveying. He should have practical knowledge of the various methods of doing topographic work and of map making. He should be a good draftsman; he should be so trained in drawing that he can, if necessary, make his own drawings and sketches, and will know, at least, how to direct the work of others. Careful attention should be given to the preparation of rock slides and their microscopic study. In paleontology he should not only be instructed in the best methods of investigation in and the application of paleontology to geologic work, but he should also have a pretty thorough acquaintance with fossil forms and their range in the geologic column.

I take it for granted that no one in this audience has any doubt in his mind about the necessity of laboratory work in training a naturalist, and I would not refer to this point at all were it not that within a couple or three months the faculty of a prominent educational institution in this country "after an exhaustive debate of three and one-half hours, decided by a vote of 6 to 5 that laboratory work in the scientific courses should not be abolished as requested by the professors of languages." Of course one would as well try to teach a student to swim without letting him go nigh the water, as to undertake to teach him natural history, chemistry or physics without laboratory work.

Besides laboratory work there is perhaps no branch of natural history which more emphatically demands field work for its students than does geology. This is due largely to the fact that the little indoor or laboratory work the geological student can do is directly and entirely dependent upon his field work. Then, too, in other studies we can have and do have our laboratories in which nearly all the student's observations are made. In botany and in zoology, in histologic studies and in chemistry and physics, the materials may be successfully studied in the laboratory, but the geologist, whose studies are often valuable in proportion to the range of his direct observations, can not take his stratigraphy and his topography into a laboratory. His laboratory, except in certain parts of petrographic and biologic studies and in the office work on his maps, is out of doors.

In its professional bearing the most essential part of a geologist's training should be to the end *that he observe well, and that in his deductions he properly subordinate his facts.* His preliminary technical training should therefore be for the purpose of teaching him accuracy and detail. The necessity of accuracy should be so deeply impressed upon his mind that accuracy will become a part of his nature. After this lesson is learned he must be taught speed, without sacrificing in the least his accuracy.

I believe Dr. Chamberlin, president of the University of Wisconsin, recently delivered an address before the Western Society of Naturalists upon multiple working hypotheses. I have not seen this address, but I can readily imagine that he presented in detail the advantages of this method of scientific investigation, in the use of which I am, myself, greatly Dr. Chamberlin's debtor. In my own experience I have found it of the greatest value and I know of no better way of developing the reasoning powers or of anticipating difficulties, or of reaching right conclusions than by the proper use of hypotheses. As the whole professional training of the geologist is for the purpose of enabling him to reach correct conclusions, he should be trained in the use of every method of investigation that will aid him, and among these aids I count as of great importance that of multiple working hypotheses.

Besides having a broad general culture, a geologist must be *par excellence* a geologist, and besides being a geologist he ought to know more about some particular branch of geology than anyone else. The material progress of our times is due largely to the division of labor which enables each individual to perfect his skill. Progress in science is due in no small degree to a similar division in scientific work. Though I can not dispense with a knowledge of chemistry, specialization by my neighbor who devotes himself to chemistry relieves me of the necessity of devoting a large part of my time to chemistry; the devotion of another to physics gives me my time for geologic work proper, which, without the specialist in physics, I should be obliged to devote to physical studies. The astronomer hands me the results of his special investigations and saves me my time for geology, which, without his help I should be obliged to give to astronomy. And so it is all around. On the other hand I trust that my attention to geology will, in its turn, come to the aid of the chemist, the physicist and the astronomer.

In saying a word for specialties I am fully aware of all that has been urged against this kind of scholarship. President White of Cornell University said to me in a private conversation a few years ago, that he had his doubts and fears about the outcome of this modern tendency among scientific men to specialization. Said he: "If this thing goes on, we shall have, after a while, a man who will know all about the stripes on a trilobite's tail, but he won't know anything else." It is very easy to ridicule a specialist, especially if the aims of his studies are not comprehended. Galvani studying the twitching of a frog's legs, Darwin breeding pigeons, and Agassiz planting sticks on a glacier, are inspiring or ridiculous in proportion as we comprehend the bearing or end of their studies. Whether studying the twitching of a frog's legs or the stripes on a trilobite's tail is an unworthy and contemptible occupation for an intelligent man depends, therefore, upon the ultimate objects of the study. And in regard to special work by those who aspire to broad culture in science I can only repeat what I have always held upon this subject: that a man who is incapable of doing and has not done special investigation is not capable of taking a broad view of science in any of its relations. Mr. Darwin has done some of the best generalizing of our age, but before he did it he had done some of the best of specializing, and that too on such unpractical, uninteresting and useless animals as the barnacles.

A lofty structure can not be built upon a narrow foundation, neither can a man be great in science who hasn't broad culture. And as only close attention to minor details in the material used can secure a great building against calamity, so care and skill in special investigations—in little things as it were—are essential to a great and broad-minded man of science.

You will probably exclaim that the requirements of which I speak and which I find essential are entirely too many to be complied with; that life is too short to allow one to undertake so much purely preliminary work. It can not be denied that to become a good geologist is a serious undertaking, and all I have to reply is that this is the kind of geologist I have been seeking and am still seeking. How many have you found? you will ask. Not many, I must confess. Indeed men with such preparations are few, and when one finds them, he dosen't find them "looking for a job;" their services are always in demand. I may say, however, that it is not to be expected that the student should get all this training as undergraduate work. College men going into law, medicine and theology, if they get the technical training required by their professions, spend two or three years in law, medical or theological schools. The geologist must do what amounts to the same thing—that is, he must, beyond his general training, qualify himself specially for geologic work. When our geologists are so trained we shall have a better science, better geologists and better results all round.

The demands that are made upon a geologist require no particular kind of an intellect, save, of course, that it be a good one, but broad culture and broad mental grasp are essential to the pronounced success of any man in any calling. A man is wanted not to work up this or that deposit as it may occur in some limited area, or this or that formation, and much less some county or other artificial area, but who, in working up a topic, can and will take up the problem as a whole, and study it as a whole, not in one locality, but wherever it may be found in the world, who can work up the bibliography of his subject, and who can sift and put to good use the facts gathered by others in his deductions, and whose knowledge of allied sciences will enable him to draw proper conclusions from his facts, while his knowledge of affairs will render his judgment upon economic questions of the greatest value.

But it is not my purpose to confine my remarks to the technical training of the geologist, but to refer also to certain general and ethical features of his work which call for a training or fitness to which educators give too little attention. I hardly know whether any instructor ever troubles himself to impress his students with the ordinary requirements of professional etiquette; I don't remember ever having heard the subject mentioned in a class-room. We seem to have depended upon men's instincts as gentlemen for shaping their professional conduct.

To be a successful geologist one must be a geologist very largely because he can't help it—because he can't keep out of it. I mean, of course, that the science must so fill the demands of his mind, his temperament, and his health, that in any other occupation he feels that he is not where he can make the most of himself and of his energies. Such men will have that professional pride without which everyone is doomed to a fatal mediocrity. The man who goes into geology because there is money in it, will, in nine cases out of ten, make a total failure of it. To be sure a living must be had, but he who has the right training, and the right interest in his work, will never lack for lucrative employment for any considerable length of time. It may sometimes happen, however, that a geologist is without such employment for a while, but it should be distinctly understood that such times are not to be given over to demoralizing idleness. The world is too full of problems of scientific interest for any man having a scientific spirit to stand idle for a single day or a single hour, and no one having such a spirit will stand idle.

In the balancing of the essentials and the non-essentials in the training of a geologist certain economic considerations have, almost without exception, to be faced. Those of us who devote ourselves to pure science are constantly being wearied with that most tiresome of all questions about the practical value of what a man reads about, thinks about, or does. So long as the young see around them examples of men who have become wealthy by the successful application of some law in science, by the invention or discovery of something that people are willing to pay handsomely for, just so long shall we have these young men asking how this and that study, this and that bit of training are going to be of any *use* to them. As men who love science for its own sake, we get weary of such questions, and some of us feel driven, in order to emphasize our warnings, to avoid the useful altogether. Thus we occasionally have, on the one hand, men who have a horror of doing anything that is liable to be of practical value, and on the other, men who have no patience with an investigation which does not promise some tangible, material reward for their pains. My opinion is that there is little to choose between in these two types. One of them is just as far wrong as the other.

There are many pitfalls in the pathway of the geologist—many inducements for him to profit just a little too much by his experience. His duties are often of a very delicate nature. He is called upon to examine and report upon properties where large sums of money are involved, and where the information obtained in his professional work might be used by him for his personal advantage. The importance of a right way of thinking and acting in this connection is of the utmost importance, for if one does not conduct himself properly just here he is liable to gain a good share of the whole world "but to lose his own soul." I am reminded to quote the man who advised his son to avoid the appearance of evil: "Never mind the evil itself, but avoid the appearance of evil." This is, of course, a perversion of good advice. "Avoid the very appearance of evil and evil will avoid you," is good advise for the geologist, as well as for other folks.

I may say briefly that a professional geologist, especially if he is in a public place, such as state geologist, or is in any way connected with a state or national survey, has no moral right to have a personal interest in any mining property, or in any other property a knowledge of the value of which might come to him through his knowledge of geology. Abstaining from such interests is a duty the geologist in public employ owes to himself as well as to the public, and the public has the right both to expect and to demand that its employés shall not walk off with the profits of its investments, just as a manufacturer has the right to demand that his employés shall not appropriate the articles they make. The geologist not in public employ who becomes personally interested in mining operations, even when he does it in the frankest, most open, and most upright manner, and with no idea of doing otherwise than as any citizen may honorably do, does nothing wrong in itself, but he must remember that he does so at the risk of his reputation and standing as a consulting geologist.

The man who is not willing—does not try—to save his energies, may be relied upon to not give the world the benefit of his best services. How often we see men who had an idea that there is some virtue in doing a thing the hard way, who, when suggestions are made for the purpose of saving their energies, assure us that that is all right, that they'll get it done, and if their way is a little harder, they are the losers by it.

A certain engineer has a three-sided scale in his drafting room. There are six different scales cut upon it. A person using this scale is liable in taking it up to turn the wrong division upon his line, and, in order to avoid this risk, and to save the time and thought that must be used in watching to see that one doesn't get the wrong side, a simple piece of metal has been devised to clasp it in such a way that it is impossible to use the wrong side. Some of his assistants remove this safety attachment, because they are not "used to it" and insist on running the risk of making mistakes and of using up the time they are paid to work, in examining their scale to see whether they have turned it over. Another man doing topographic work doesn't want to signal to his assistant, preferring to call out his directions to him at long distances, often more than a quarter of a mile, so that at the end of the day he has done three-quarters of a day's work on the topography, and the other quarter in yelling—a bit of labor the geologist can not utilize. These mistakes are unpardonable errors of judgment, and young men should be warned against such. If we spend our time and energy in unnecessary work we shall have just so much the less energy for the essential. There may be some excuse for the man who isn't able to discriminate between the essential and the non-essential, but in such cases as those referred to, and indeed in the majority of cases that arise, there can be no such question. In his methods the geologist must always be willing to profit by the experience of others. Methods and appliances of research are constantly being improved, but these improvements are made, not by disregarding the experience of others, but by making every possible use of it.

There is sometimes a tendency among the newly fledged to imagine that those who have gone before them have not taken the greatest pains in their work, that their conclusions have not been warranted. They therefore begin with the idea that by the application of superior, or at any rate, new methods of investigation, they are going to upset everything done before they began. Such persons often succeed in making asses of themselves, and end their careers before they begin them—that is, they make careers impossible.

I had occasion recently to go over the work of one of our older geologists—work done under the most adverse circumstances. This work had but a short time before been very sharply criticised by an aspiring young geologist, and I was prepared to find either one of them right. I not only found the work of the older geologist well done, but I was astonished at the clearness of his perceptions and the general reliability of his conclusions. The young man had committed a blunder from which his reputation can never recover.

The necessity of caution on the part of the young geologist in publishing conclusions that one feels to be open to criticism, or when he sees that important facts may be overlooked, can not be too strongly emphasized. The publication of facts is generally most useful, but deductions can afford to wait until they are properly matured. A most valuable piece of advice once given me was to the effect, that young people would better not begin pumping out of their intellectual reservoirs before something has been pumped into them. Life is too short, and progress all along the line is too slow for us to cumber the march of science with verbose discussions which help toward strife and contention instead of towards truth and union. To be sure "ignorance is no reason with a fool for holding his tongue," but my advice is not intended for fools, who will be fools in spite of everybody and everything, but for those who, having sound sense, desire not to appear fools or to bring discredit upon themselves or upon the science to which they are devoted.

Science is not infrequently charged with vacillation. Apropos of this, one of our humorists has the following: "Science says—but no matter what science says, for the next time she says anything she'll say just the opposite." We cannot deny the justice of the criticism, but this bad repute is to be attributed entirely to premature utterances, We have some sad examples in this country of poor geologists whose premature conclusions, drawn from too hasty or incomplete work, have kept half a dozen good geologists busy for years in correcting their mistakes and in putting the truth before the world. Their excursions into geologic fields are like the inroads of lawless and unclean animals that require a score of persons to clean up and put things straight after them. These busybodies have, almost without exception, an itching for notoriety that leads them to seek some scientific short-cut by which to arrive at distinction, but if there is a balancing of accounts either here or hereafter, these men are destined to have a distinction in the scientific world of quite another sort from that for which they are pining. They are usually men of good enough intentions,but, as one of my preceptors once reminded me: "we have a right to expect something more than good intentions of men." All people mean well; it is our business to *do* well.

Sensationalism has done and is doing great injury not only to geology but to other branches of science. There are certain features about every science that impress the ignorant with their novelty, and there are certain persons who are always ready to make capital out of them. This gives rise to a sort of "O my!" class of men and to an "O my!" kind of science. They delight in the startling. None of the more radical theories of science, theories put forward by the right thinking with great caution, stagger them. Man's descending from a monkey never troubled them; they always thought so, and can point out cases of descent that would make Mr. Darwin or Mr. Wallace catch his breath. This skimming the surface, this dilettanteism is strong in our times. In the geologist's training the less we have of the sensational the better it will be for the science and for the man.

It is not a pleasant thing to be obliged to destroy the delusions which people hold so lovingly close to their hearts, but the conscientious geologist has a good deal of this disenchanting to do. And nobody even thanks him for it. The very persons he may hope to serve in telling them the truth, will, in all probability, never believe him and never forgive him.

But a geologist has to face a great many disagreeable duties, and if he hasn't the moral courage to tell the plain, unvarnished truth, and to take the consequences, when a white lie would smooth matters over all round, he will find his troubles increasing as time goes on. One lie, whether it is a white one or a black one, only makes room for two others, and the man who makes two lies grow where but one grew before deserves no good of mankind.

Those who are at once workers in science and teachers of science know how difficult it sometimes is to draw a sharp line between what we know and what we simply believe, but as far as possible this distinction should always be kept before the minds of students, and no effort should be spared to prevent that dazzling of their minds which prevents them from weighing evidence and from distinguishing between simple truth and simple figments of the imagination.

And now just a word about our responsibilities to our own intellects. Intellect is the tool with which the geologist has to do his work. If that tool is bent out of shape or dulled by improper use it cannot perform its functions properly. It is highly essential therefore that he keep his intellect unimpaired. He should strive to keep his mind free from those tricks of logic, rhetoric and sentiment by which so many of us allow ourselves to be imposed upon. Those of us who are naturalists and investigators at heart, as well as by profession, are not satisfied with declaring, like the humorist, that we are "open to conviction," while parenthetically we add, "but we'd just like to see the man who can convince us." We are bound by every sentiment of honesty to go where our evidence leads us, whether it takes us to a pleasant place or not. Truth must be our companion whether she be an agreeable or a disagreeable one—a handsome or an ugly one. We cannot honestly say to reason, "thus far shalt thou go, but no farther." We can't reasonably follow the science of geology to a certain point and then abandon it for the divining rod or spiritualistic seances or clap-trap appliances of any kind. The man who has no notion of accepting the results of his reasoning would just as well not reason at all, while the man who undertakes to reason within certain limits insults his intelligence. All honest men are seeking the truth ; and is it not our duty to help others in this search when we can? We may be sure that if we wait till all the world thinks alike, the world will never care what we think.

I have said that the profession of a geologist requires certain proficiencies that are common to successful men in any and all occupations in life. Good judgment, clear insight, business habits of thought, and promptness of decision and action are as essential in geology as anywhere else, and it has often seemed to me to be even vastly more so. It is not enough that one should plod faithfully ahead with a task—though faithful plodding is not to be underestimated at all. The man who grasps a subject in all its bearings, takes hold of it with judgment and solves its problems with courage and logic is the one who really advances the cause of truth, the cause of science and the cause of humanity.

Once upon a time a business house employed a young man whose energy and grasp of the business of the firm induced the head of the house to promote him more rapidly than an old and faithful employe. The old employe felt deeply hurt that this dapper young fellow, who parted his hair in the middle and wore eye-glasses, should be advanced over him, and he took occasion to complain of it to the senior partner. The senior partner felt it to be a case that he couldn't very well argue with so faithful and tried a servant. There happened to be a lot of wagons passing the door of their building at the moment, and, as if changing the topic for a minute, he asked the old clerk what was making all that noise. He went forward and returning told the partner that it was a lot of wagons going by. He then asked the clerk what the wagons were loaded with. He went out again and returned and reported that they carried wheat. He sent him again to know how many there were of them. He returned with the reply that there were 16. Again he sent him to ascertain whence they came, and he returned saying they were from the city of Blank. The senior partner then asked the clerk to be seated, and sending for the young man complained of said: "Will you see what the meaning is of that rumbling noise in front." The young man replied: "It will not be necessary, for I have already ascertained. It is caused by some wagons—36 in all—16 in this lot, but 20 more to pass to-morrow. They belong to Pinto & Rosa of the city of Blank and are loaded with wheat. They are on the way from Blank to Zee where the

This illustrates the demands, not of busine
of geologists, and of everyone who emplo
directly or indirectly, or who associates other
his work. We all want men who can not
best and most comprehensive scientific wo
prehend their duties in all their relations,
with prompt and clear judgment, and save
gies for other affairs. And we don't want
order to get out of a man what there is in h
him constantly and to direct his every effort.

THE TRIASSIC FLORA OF RICHMON

By Jules Marcou, Cambridge, Mass

The publication of four papers, lately is
Fontaine, Zeiller, Stur and Newberry,[1] ha
my memory reminiscences and facts which
torically and critically those who may study
has been done until now, the coal formation
Richmond and in general the whole Trias o

First period, 1834-1848.—In 1834 the lear
ogist and mining engineer R. C. Taylor, a
celebrated Strata Smith, the father of Englis
the coal series of Richmond—with some d
the old Coal Measures of the Carboniferous s
and Wales. (*Trans. Geol. Soc. Pennsylva*

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[1] *Contributions to the knowledge of the older Mesoz*
by William M. Fontaine, 4to, Washington, 1883,
1885, U. S. Geol. Sur. Monographs VI.

Dr. Newberry in his review of "Geological equivalents of our Triassic rocks," (*Mon. cit.* p. 8) says: "A single one of the abundant fossil plants which occur in the Richmond coal basin would, however, have been sufficient to show the error of this opinion." This remark is unjust, and at the same time a gross exaggeration of what was then the status of our knowledge of palæophytology. No one was more anxious to make application of the test of organic remains, in determining the age of the rocks than Taylor, "an original disciple of William Smith," as he calls himself in his very remarkable book, *Statistics of Coal*, p. 46, Philadelphia, 1848. Adolphe Brongniart, the true founder of palæophytology, in his *Végétaux fossils*, in course of publication, 1828-1837, had referred a fossil plant from Richmond to the *Calamites suckowii*, a characteristic species of the Coal Measures of England, Wales and Pennsylvania, only he made a variety of it, and it was not until many years afterward that it was proved to be a new species and even a new genus, *Schizoneura* Schimper (*Sch. planicostata*), instead of being only a variety of *Calamites suckowii*. Nuttal many years before, 1820, in the "Journal Acad. Nat. Sciences," Philadelphia, vol. II, part I, p. 36 of his excellent paper, *Observations on the geological structure of the valley of the Mississippi*, had recognized *Zamia* or *Cycas*, *Equiseta* and *Scitamineæ* from the coal basin of Richmond, as well as remains of fossil fishes; at a time when the significance of palæontological characters was in its infancy, and before the material possibility of appreciating it existed; for we must remember that in 1816, when Nuttal made his observations round Richmond, we possessed neither of the fundamental works of Adolphe Brongniart, and Louis Agassiz. And if to-day it is easy, with a single plant of Richmond to show the error of the opinions expressed in 1834 by Taylor, it is due to the studies of two and even three generations of palæotophylogists. Even with our present knowledge it is not always easy to determine with accuracy the age of a coal bed, with only *one* and even *seven* species of plants, as is amply proved by the "Jurassic florula" of Dr. Newberry, found by him at the Moquis Pueblo in 1858, which he referred first to the Jura, then to the Trias, and now passed over without any notice, in *Mon. cit.*, as if it did not exist, showing plainly enough that Dr. Newberry does not know what to do with it, and that *seven*, not a single *one*, of the abundant fossil plants occurring in the coal of Moquis, do not suffice to Dr. Newberry himself, notwithstanding his stricture on Taylor's view.

In 1843 William B. Rogers referred the "coal of eastern Virginia to a place in the Oölite system on the same general parallel with the Carboniferous beds of Whitby and Brora—that is, in the lower part of the Oölite group." (*On the age of the coal rocks of eastern Virginia*, in "Trans. Assoc. Amer. Geologists," vol. I, p. 300, Boston, 1843). He based his views more especially on the *Equisetum columnare*, Brong., *Jæniopteris whitbiensis* and some *Zamites*.

Charles Lyell, in 1847, in a paper entitled: *On the structure and probable age of the coal field of the James river near Richmond, Virginia.* ("Quart. Jour. Geol. Soc. London," vol. III, p. 261) arrived at the same conclusion as William B. Rogers, adding: "If future researches should require any modification of this opinion, we may then expect that the Trias will be the group to which the American formation will be referable." Three fossil fishes collected by Lyell in December, 1845, were referred by Agassiz to the age of the Lias. And C. J. F. Bunbury regarded the geological evidence afforded by the fossil plants as to a certain degree ambiguous.* "On the whole," he says, "we may say with tolerable confidence that the Richmond coal field belongs either to the Triassic or to the Jurassic series." ("Quart. Jour. Geol. Soc. London," vol. III, p. 288).

Henry D. Rogers, in 1848, read a paper before the British Association for the Advancement of Science, in which he maintained the Jurassic age of the Richmond coal field, referring it to the Inferior Oölite and even to the Great Oölite.

Professor Newberry in his "Geological equivalents" p. 9 of the *Mon. cit.* says: "Profs. W. B. Rogers and H. D. Rogers were led by the general resemblance of the ferns and cycads of the Richmond basin to those of the Lias of Whitby, England, to consider these rocks Liassic, that is, Lower Jurassic." The whole is incorrect, for the coal of Whitby has never been considered as belonging to the Lias, and was not called Liassic by the brothers Rogers, who did not refer the rocks of the Richmond basin to the Lias, but to the Lower Oölite and even to the Great Oölite.

Such was our knowledge of the age of the eastern Virginia coal field in 1848. Taylor thought, with some doubt, that they belonged to the Coal Measures, in his first paper of 1834, and in his *Statistics of coal* of 1848 he seems to adopt Lyell and Bunbury's reference to the Jurassic series; and the brothers Rogers and Lyell regarded them as the equivalent of the Lower Oölite coal of Whitby in Yorkshire, and Brora in Scotland.

SECOND PERIOD, 1849-1882.—In April, 1849, I made a careful exploration of a part of the Richmond coal field, round the mines of Gowrie, Mid-lothian and Blackheath pits, collecting a great number of fossil plants, and a few fossil fishes. When there my impression was that the series of strata belonged to the Trias. The upper portion of the series, more especially on account of the great quantity *Equisetum* related to *Eq. columnare* and of a *Calamites* related to *Cal. arenaceus*, reminded me in the most striking way of the coal field of the Keuper of Franche-Comté, and of the Basel canton (Switzerland), and of the Schilfsandsteine (Reed-cane sandstone) of the vicinity of Stuttgart and Tübingen.

After my researches in the field, I visited at Philadelphia, in company with professor Louis Agassiz—who was then delivering a course of lectures there—Mr. Richard C. Taylor, who asked my opinion upon the age of the Richmond coal field, I said that it was Triassic, and the upper part of the series of strata, just at the opening of the Mid-lothian coal pit, was certainly Keuperian. Taylor seemed to agree with me, saying that he had abandoned the idea that it was the Coal Measures; but that it seemed to him older than the Whitby formation of Yorkshire, well known to him. Agassiz was very sure that the fossil fishes belonged to forms indicating the Liassic age, but not more recent at all events.

I wrote then a paper entitled: *Note sur la homille du comté de Chesterfield près de Richmond,* which was published in the "Bulletin Soc. Geol. France," vol. VI, Juin, 1849, containing the following conclusions: "I am inclined to think that the coal formation of the vicinity of Richmond is older than the Lower Oölite, and belongs either to the Keuper or the Lias, with a greater probability in favor of the Lias, on account of the fossil fishes."

As a practical geologist, my opinion was that the coal formation of Richmond was the equivalent of the European Trias.

But being a young man, and knowing the great leaning toward the complete uniformity of palæontological rules, which prevailed in geology since 1836, I reluctantly accepted. as a compromise, the Lias age as the probable one. Having lived in the intimacy of Alcide d'Orbigny, Louis Agassiz, de Verneuil, and de Koninck, all of whom then thought and professed that the same forms of fossils extended at the same time all over the world, disappeared all at the same moment, and were replaced directly by a special creation of new forms; it was too much for me to oppose their views, although some facts had come already to my knowledge during my researches in the field in Europe and in America, which were contrary to that easy and sweeping doctrine; and it was not until Barrande had demonstrated the existence of colonies, and Deshayes had maintained with more proofs, his old opinion, that forms, and sometimes even species, pass from one group to another, and even from one system to another, that I had the courage to state my views and observations, without being influenced any more by the uniformist theory.

In my *Geological map of the United States and the British provinces of North America, with an explanatory text*, etc., published in Boston, June, 1853, I represented the coal field of Richmond as Liassic.

But during my exploration of the 35th parallel of latitude across the whole continent, I met the Trias and studied it on such a vast surface that I had no more hesitation; and from that date, 1853-1854, I have classified the coal series of Richmond with the Trias, as the equivalent and homotaxis of the European Keuper, (*Résumé of a geological reminiscence extending from Napoleon at the junction of the Arkansas with the Mississippi to the Pueblo de Los Angeles in California*, House Documents, 129, pp. 40-48, Washington, 1855; and *Résumé explicatif d'une carte géologique des Etats-Unis*, etc., in "Bulletin Soc. Geol. France," vol. XII, pp. 871-872, Mai, 1855, Paris).

About the same time Dr. E. Emmons was studying the coal series of North Carolina, and in his *First Report of the geological survey of North Carolina*, Raleigh, 1852, at p. 143, he says that the coal rocks of North Carolina (Deep river coal) belong to the "Upper New Red sandstone," which is the Keuper. Misled by the erroneous classification of Murchison for the Trias and Dyas of Russia, confounded and placed into a single system, under the name Permian, Emmons, at p. 159, (*loc. cit.*) inclines to adopt the view that "the coals of Deep and Dan rivers are Permian."

I was not aware of the existence of that report until 1860, when Dr. Emmons wrote me from Raleigh in November: "I sent the other day my report for 1852, which is so shabby that I hated to send it to decent men," on account of bad printing.

I took advantage of my stay in Zürich to submit to my friend and colleague at the federal Polytechnic School, Oswald Heer, some of my specimens of fossil plants from Richmond and asked his opinion. Heer studied carefully a few—only three—of my specimens, and all the plates published by W. B. Rogers, Bunbury and Emmons; and his conclusions were that the coal flora of Richmond is contemporaneous with the flora of the Keuper of Würtemberg, Switzerland and Bavaria, agreeing entirely with my view published twice before in 1854 and 1855 at Washington and in Paris. Heer wrote me an open letter on the subject, dated Zürich, July 25th, 1857, which I have published in my *Geology of North America*, at p. 16, 4to, Zürich, 1858. Dr. Emmons, having asked me as a favor to send him a copy of that letter—before the issue of my book then already going through the press—I complied with his request, and he communicated it to his old friend and predecessor at Williams college, professor C. Dewey. Without asking my permission Dewey arranged with Mr. James D. Dana, a publication of that letter, using at the same time my own letter to Emmons, and the whole appeared in the "Amer. Jour. Sci." vol XXIV, p. 428, 1857, under the initials C. D., with *Additional remarks by J. D. Dana.* My name is struck out from the letter of Heer, addressed to me, and instead it is said that Heer examined professor Emmons' specimens from North Carolina and forwarded his conclusions to him, two errors absolutely inexcusable, for Messrs. Dewey and Dana had in their hands, first, my letter to Emmons, from which they made quotations, and second, the copy of the letter from Heer to me, with my address on it.

Dr. Emmons wrote me, Oct. 24, 1857, from Raleigh: "I have been extremely gratified at what has ultimately taken place (in regard to Lyell accepting the age of the Richmond coal field as Keuper), and which yourself and professor Heer have been instrumental in bringing about. It will do much to settle our geology on a true basis." In another letter, dated Albany, August 29, 1860: "It seems something wrong took place in the publication of professor Heer's letter to you in *Sillman's Journal.* I thought that professor Dewey would state exactly how that letter came into my hands, for I gave him your letter also". Finally in another letter dated March 12, 1859, Dr. Emmons says: "I am much obliged to you for your work on the *Geology of North America.* It was of great service to me as I availed myself of all the kind expressions relative to me. It saved, I think, the survey of North Carolina from going by the board. * * * * Shall we, in this country, have the fortune to be reinforced by your future residence here? We are sadly off for men of the true stamp. I have heard professor Henry express his regrets at what has taken place here in regard to yourself, who I know entertains for you the highest respect."

In résumé, in 1849, when on the field near Richmond, I parallelized the coal beds there, with the Keuperian coal of eastern France, Switzerland and Würtemberg; regarding the upper part of the series of Richmond as the equivalent and homotaxis of the whole Keuper or Upper Trias. After my two notices of 1849 and 1853, in which I hesitated to refer those rocks to the Keuper or the Lias, on account of fossil fishes considered as Liassic by Agassiz, I took a definite conclusion in 1854, after my return from my exploration by the 35th parallel of latitude, and placed them as the upper part of the Trias, or American Keuper of the Atlantic states.

Without knowing my researches, nor publications, Dr. Emmons, first in 1852, and afterward in 1857, came to the same conclusion, referring the coal formation of Richmond and North Carolina to the Dyas and Trias. He found two series of strata, the Chatham series and the coal of Dan river, 5,000 feet of thickness in North Carolina, containing fossil animals and plants indicating great lacustrine and brackish water deposits, analogous and of the same age as the upper Dyas and the whole Trias of Germany, England, France and Russia.

In comparing our publications in 1860, we agreed on the age of the series of strata of the coal formations of the vicinity of Richmond and North Carolina, regarding them as the equivalent of the whole Trias of Europe, and the upper part of the Dyas at least, perhaps the whole Dyas. Emmons and I walked hand in hand on that question, as we shortly after harmonized entirely on the primordial fauna and the Taconic question. The disappearance and death of my friend Emmons, during the great civil war, has left me alone to maintain our views and observations. I have done all that was in my limited power to sustain the correctness of our observations, and have tried to give an exact chronological order of American stratigraphy, a primary want, without which all is confusion and chaotic. To be sure I have also tried to have our right of priority on all difficult questions on which we have made most important discoveries, recognized; and so far I am satisfied of the great progress made since 1885. Emmons' great discovery of the Taconic system,of the Primordial fauna, of the Trias of North Carolina and of the upper Dyas (Chatham series) are in a fair way of being accepted and used by the majority of geologists. As to my own discoveries, I feel sure also that they will be, in time, admitted and referred rightly; for after all, truth and honesty get always the upper hand, notwithstanding all opposition and unfair dealing of not over scrupulous adversaries.

To that second period belong the two editions of my *Geological map of the world*, 1861 and 1875, in which I have colored the coal basins of Richmond and North Carolina as belonging to the New Red sandstone (Dyas and Trias) epoch: and in my *Explication d'une second édition de la carte géologique de la Terre*, Zurich, 1875, 4to, pp. 43-49, I have maintained the age of the Dyas and Trias, as observed and determined by Emmons, Heer and myself.

Third period, 1883-1889.—Lately the United States Geological Survey has issued two monographs by Messrs. W. M. Fontaine and J. S. Newberry, on the coal series of the vicinity of Richmond, which so far as practical geology and American classification are concerned, are a step backward and in a wrong direction.

Professor Fontaine's memoir is entitled: *Older Mesozoic flora of Virginia*, Washington, 4to, 1883, only issued in February, 1885; forty-two plants from Virginia are described and figured. Probably the original drawings were good, but the plates are poorly executed, and on the whole the illustrations of that Virginian flora do not render justice to the beautiful specimens of those fossil plants. The descriptions are generally good; only the reference to species and even to genera may be improved, as has been shown by professor Zeiller of the School of Mines, of Paris, and by Mr. D. Stur, the director of the geological survey of Austro-Hungary.

The paper of director Stur (*loc. cit.*) is a very important and just review and criticism of professor Fontaine's monograph. Without entering into details, I shall only remark, that to my great satisfaction, director Stur refers the very common *Equisetum* of Virginia to the *Eq. arenaceum* of the vicinity of Stuttgart, as I did in 1849; and also the very abundant and characteristic *Calamites* to *Cal. meriani* of the Swiss Keuper. According to Mr. Stur's careful determination of the specimens of Virginia put into his hands by the director of the United States geological survey, several of the species named by professor Fontaine pass into synonymy, having been described by Brongniart, Jaeger, Kurr, Heer and Stur. From the tables published by Messrs. Fontaine and Stur, showing the names of the Virginia plants and their affinities, it is certain that we have there a Keuper flora, well characterized, representing and the equivalent of the Lettenkohl flora of Lunz and Raibl. As the plants in Virginia range and are distributed all over the one thousand feet thickness of the upper strata, being more concentrated, however, at about seven hundred feet below the superior sandstone, just as in southern Tyrol, we can say, without the least doubt, that the coal fields of eastern Virginia are the equivalent of the whole Keuper of Europe, and that the flora represents the flora of the Lettenkohl of Germany, as Emmons said as far back as 1852, using exactly the same name of *Lettenkohl* in his first report of the geological survey of North Carolina. Professor Fontaine thinks the Virginia flora is not older than Rhætic. That is to say, that the coal series of Richmond belong and are the equivalent of the Rhætic formation of Europe. The Rhætic is simply the "*Avicula contorta* zone," or Infra-Lias, or third division of my superior stage of the Keuper of the "Jura Salinois;" the color and uppermost type of the Trias; an extremely limited subdivision of the fifth order, whose average thickness in central Europe is only twenty to thirty feet, while in Virginia and North Carolina the series of strata forming the coal field are four or five thousand feet thick; that is to say, a formation of the first order or system, with fossil plants and fossil animals scattered at different elevations, belonging to forms which in Europe range from the Dyas to the Rhætic. Such a narrow interpretation of palæophytology, according to proportion of a few species—even not very reliable as to their exact determination and affinity—if accepted in classification will nullify practical geology and stratigraphic researches. For, then, our table of classification and nomenclature will have to depend only on the present status of a certain class of palæontologists, and of fossil-finders in some places, only imperfectly explored. Twenty-five feet of a standard typical sub-group of western Europe can not be extended into five thousand feet in another part of the world, with the suppression at the same time of all the rest of the system in which the small sub-group of twenty-five feet is enclosed. For such is the true meaning of professor Fontaine's classification in referring the five thousand feet of all the older Mesozoic strata of Virginia and North Carolina to the Rhætic only, and not to the whole Trias. With such principles comparative stratigraphy between Europe and other parts of the world will be absolutely useless. In fact it will be the abandonment of all the rules used in geology, and with which that science has been built up from the days of Werner, Smith, Brongniart, to those of Berrande and Emmons.

In his monograph professor Fontaine has given almost *verbatim* the descriptions of Emmons' coal plants of North Carolina, from page 97 to page 128; reproducing also all Emmons' figures, copied from *American geology*, Part VI. He accepts forty species of Emmons and concludes, even with more force than for Virginia, that the flora of North Carolina "can not be older than Rhætic;" adding: "We are then, I think, entitled to consider that the older Mesozoic flora of North Carolina and Virginia is most probably Rhætic in age, and certainly not older. Some authors hold that the Rhætic beds form the uppermost of the Triassic strata. Others think that they are transition beds, having more affinity with the Lower Lias. The latter view will, I think, be justified by a study of the flora, and I have, in this memoir, assumed its correctness. (*Loc. cit.* p. 128.)

It is simply an attempt to return, as far as it is possible to do, without nullifying almost all the palæophytologic characters, to the Jurassic opinion expressed by William B. Rogers and defended by Henry D. Rogers and James Hall.[2] The papers by professor Zeiller and director Stur sufficiently repel this move backward toward an error given up, by Lyell, as far back as 1857, when on a visit to me at Zürich. (*Geology of North America, etc.* p. 16.)

The monograph of Dr. Newberry entitled: *Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley*, 4to, Washington, 1888, received lately, November, 1889, although confined in the title to Connecticut and New Jersey, treats also in a special chapter, "Geological sketch," of the age of the coal beds of Richmond and North Carolina. As it was to be expected, Dr. Newberry tries to enforce as much as he can the conclusions and researches of professor Fontaine, and at the same time to diminish the value of the researches and conclusions arrived at by Emmons and myself. However, he goes too far when he says: "Many figures and descriptions of the remains of both plants and animals were also published by Prof. Ebenezer Emmons in his geological report of the midland counties of North Carolina in 1856, but, though deservedly eminent as a geologist, professor Emmons had little acquaintance with palæontology, and this contribution rather increased than satisfied the desire for more thorough knowledge of the life of the Atlantic coast in Mesozoic times. No systematic collection nor thorough study of the fauna or flora of the formation as a whole was attempted until about 1880, when Prof. W.M. Fontaine, of the University of Virginia, began a careful review of the fossil plants of the Virginia and North Carolina Mesozoic coal basins. His results were published in a memoir on "The older Mesozoic flora of Virginia, which was issued in 1883, as volume 4 of the monographs of the U. S. geological survey. This threw a *flood of light* upon the vegetation of the Atlantic coast in the Mesozoic ages and established beyond question the parallelism of our New Red sandstone with the Keuper of Europe; a matter which has been much debated with somewhat discordant conclusions, by Hitchcock, the brothers Rogers, Lyell, Marcou and Emmons." (*Loc. cit.* pp. XI and XII.)

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[2] *Red sandstone of the Connecticut river valley, and the proof of its Oölitic or Liassic age.* ("Proceed. Amer. Ass. Ad. Science," Washington, 1854, p. 290. The paper was not printed and has remained in manuscript to this day, which is very regretable, for in it we might have found a "flood of light."

First, Dr. Newberry thinks that "professor Emmons had little acquaintance with palæontology," the most extraordinarily incorrect statement ever made against numerous and plain facts. I shall only say that Emmons created the Primordial fauna, as a special fauna, in which all his determinations and descriptions of species and genera are good and recognized as such by the two best palæontologic experts for palæozoic animals, Joachinn Barrande and J.W. Salter; while all his adversaries, even to this day, have blundered constantly and made the most glaring and unexcusable mistakes in their attempt at determining Taconic fossils. Dr. Emmons' description of the oldest mammalia yet found in the world, the *Dromatherium sylvestre*, used and accepted by all palæontologists, is another instance of his great acquaintance and thorough knowledge of palæontology. Finally his description of fossil plants of North Carolina, copied *verbatim* by professor Fontaine, and quoted by all palæophytologists in the world, have inscribed forever Dr. Emmons' name among the pioneers and good describers of fossil plants.

Second, to say that "no systematic collection nor thorough study of the fauna or flora of the formation as a whole was attempted until about 1880, when Prof. W. M. Fontaine, of the University of Virginia, began a careful review of the fossil plants of the Virginia and North Carolina Mesozoic coal basins," is an unjustifiable attempt to pass over the careful researches of all those who have preceded Prof. Fontaine. Not only W. B. Rogers made "systematic collection and thorough study of the fauna and flora" of that formation, but also Lyell did it, Marcou did it, and Emmons did it, and our collections, put together, are far above and much better than the one made by Prof. Fontaine, for the very simple reason that we were the first collectors, and that some coal pits, very rich in fossil plants and fossil fishes, like Gowrie and Blackheath, were abandoned long before Prof. Fontaine's explorations, and he found there only the remaining broken and poor specimens among the rubbish and debris.

My large collection, sent in 1849 to the Jardin des Plantes of Paris, was never published. Adolphe Brongniart scattered a part of it among the general and immense collection of fossil plants of the national museum of natural history according to genera, giving them names, which have remained unpublished; but which may be found there and perhaps utilized in the future. Of course all the new species found by me in 1849, and only named by Ad. Brongniart. have been described and figured since by Emmons and Fontaine. At the laboratory of geology, in the Jardin des Plantes, the bulk of my collection has been preserved together, where it fills up ten or twelve draws. M. R. Zeiller, professor of palæophytology at the School of Mines, in Paris, has lately studied my collection and he wrote me:

PARIS, 24 February, 1889.

DEAR SIR AND COLLEAGUE. * * * * "I have studied with great pleasure and interest your collection preserved in the gallery of geology. The assistant of M. Daubrée, to whom I made an application, placed directly before me all the drawers containing your collection of fossil plants of the coal basin of Richmond. But all the species have been described already by Rogers, Emmons or Fontaine. Here is the list:

Equisetum rogersi Schimp. or *Eq. arenaceum* Jaeg.
Macrotæniopteris magnifolia Rogers.
Acrostichides linneæfolius Bunbury.
Acrost. rhombifolius Fontaine.
Acrost. microphylius Fontaine *var.*
Asterocarpus virginiensis Fontaine. (Splendid specimens.)
Ast. platyrrhochys Fontaine *var.*

Besides I have found a *Pterophyllum* with very narrow leaflets, allied to some of the figures published by Mr. Fontaine under the name *Ctenophyllum braunianum*, but certainly identical to a species of the Trias of Lunz, the *Pterophyllum riegesi* Stur.

In studying the excellent figures of Emmons, very roughly reproduced by Fontaine, I have been led to contest several of the attributions and determinations of the latter, more especially about the *Albertia*, which Fontaine wants to make an *Otozamites*. The *Albertia latifolia* of Emmons is certainly an *Albertia* related to both *Alb. latifolia* and *Alb. brauni*; and until now all the *Albertiæ* have been found in Europe in the Bunter sandstein or Lower Trias."

Very sincerely yours,
RENÉ ZEILLER.

Professor Zeiller in an excellent paper: *Sur la présence, dans le Grès Bigarré des Vosges de l'*ACROSTICHIDES RHOMBIFOLIUS *Fontaine*. (Bulletin Soc. Géol. France, vol. XXI, p. 693, Paris, 1888), shows that all the types of fossil plants of Richmond and North Carolina belong to the Trias, ranging from the

Bunter sandstein or Lower Trias, to the Lettenkohl or Upper Trias; while on the contrary all the types of plants special and not characteristic of the Rhætic of Europe and Asia, such as *Dictyophyllum*, *Pterozamites* and *Nilssonia* are completely wanting in Virginia and North Carolina. Prof. Zeiller does not hesitate in agreeing with Heer, Emmons and myself, as to the age of the Keuper for the coal series of Richmond and North Carolina, synchronising these rocks with those of Basel, Stuttgart and Lunz.

About the same time director Dionys Stur of the geological survey of Austria arrived exactly at the same conclusion, in his important paper: "Die Lunzer—(Lettenkohlen)—Flora in den *Older Mesozoic beds of the coal fields of eastern Virginia*" (Verhandlungen der k. k. geologischen Reichsanstalt, Nr. 10, 1888, Vienna.)

Third; the supposed "*flood of light* upon the vegetation of the Atlantic coast in the Mesozoic ages" thrown by Prof. Fontaine, and that he "established beyond question the parallelism of our New Red sandstone with the Keuper of Europe," is a very partial, and on the whole, incorrect opinion, for the work was done thirty years before by Heer, Emmons and myself. But more, professor Fontaine does not parallelize our Virginia New Red sandstone with the European Keuper, but with the Rhætic, taking special care to refer the Rhætic to the Lower Lias or Jurassic, and not to the Keuper or Trias.

Farther on Dr. Newberry tries to make a sort of compromise about the age and classification of the Rhætic, saying at p. 11, (*Loc. cit.*): "The Rhætic, formerly included in the Keuper, is known to form beds of passage between the Trias and the Lias, though with a still prevailing Triassic facies." There Dr. Newberry's view conflicts with professor Fontaine's final and last conclusion, to place the Rhætic in the Jurassic system. It is almost superfluous to add that the Rhætic is not a group of "beds of passage," but that it is still included in the Keuper by the majority of geologists who have practically studied it in the field, and that as far back as 1845, many years before the name Rhætic was created by my friend Gümbel, the director of the geological survey of Bavaria, I classified and described all the strata of that group in the French Keuper of the Jura mountains.

At the end of his chapter, "Geological notes," Dr. Newberry makes a last effort to strike out my Jurassic discovery in New Mexico, in order to maintain his saying of 1859: 1, that he failed to recognize the Jurassic formation in any of the localities where it has been said to occur by Mr. Marcou; 2, that he found northeast of Galisteo, dicotyledonous leaves in the Jurassic sandstone of Marcou; 3, that he found also in several places of northern and central New Mexico the *Gryphæa pitcheri* of the Texas Neocomian, in places where Marcou referred erroneously the strata to his "supposed Jurassic; and 4, finally that he has "shown Marcou's so-called Jurassic to be Cretaceous." Dr. Newberry claims that a "set of beds overlying the Trias and underlying the Dakota sandstones occur in Utah, Colorado and Wyoming, and are proved by their fossils to be Jurassic. "But these beds wedge out toward the south, and I have been unable to find any traces of them south of Enchanted Springs, near the lower line of Colorado." (*Loc. cit.* p. 15.)

After my exploration of 1853, and the explorations in 1888 and 1889 of the Tucumcari area by professors Robert T. Hill and Alpheus Hyatt, confirming in every respect my discovery of the Jurassic system by proved fossils, more especially the *Gryphæa dilatata* var. *Tucumcarii*; and the *Geological map of Northwestern New Mexico* by captain Clarence E. Dutton (U. S. Geol. Surv., Sixth Annual Report for 1884-85, Washington), the reaffirmation by Dr. Newberry, that he did find no traces of the Jurassic in New Mexico, does not require any commentary; to quote it is sufficient.

Cambridge, Mass., December, 1889.

NOTE ON THE OCCURRENCE OF NATIVE COPPER IN THE ANIMIKIE ROCKS OF THUNDER BAY.

By Andrew C. Lawson, Ottawa, Ont.

Among the rock formations of lake Superior, the Keweenawan or Nipigon series has long been recognized as strongly characterized and differentiated from older and newer rocks, by the occurrence of deposits of native copper. So distinctive have these features appeared that a common synonym for the series is "The copper-bearing rocks." No occurrence of native copper in the Animikie rocks has, so far as the author is aware, been recorded. Any facts therefore, which indicate that native copper is not peculiar to the Keweenawan series, but occurs under somewhat analogous conditions in association with the Animikie rocks, which underlie it, will be received with interest both by geologists and miners familiar with lake Superior. Such facts have come under the notice of the writer during the past season, and it is here proposed to give a brief account of them since it will be some considerable time before a systematic report of the geology of the region can be published.

Field occurrence:—Along the west side of S. W. ¼ Sec. 8. Con. VI. in the township of Blake, District of Thunder Bay, runs a north and south trending ridge which presents an abrupt escarpment about two hundred feet high facing the east. To the west of the brink of the escarpment the surface slopes gradually to the old Pigeon River road. The section exposed in the face of the escarpment is very characteristic of all the numerous similar escarpments of this portion of the country and consists of about 150 ft. of nearly flat lying black shales and thin gray siliceous beds of the Animikie series, capped by about 50 ft. of vertically columnar diabase trap, Near the south end of the quarter section, there is an indentation or bay in the face of the escarpment affording a steep slope whereby it may be ascended from the valley to the east. At the foot of this slope some Indian prospectors found some pieces of amygdaloidal trap carrying native copper, which were brought to my notice at Port Arthur by Mr. C. Johnson, who had become interested in the find. In company with Mr. Johnson and his Indian guide I visited the ground last October, and found extending up the surface of this slope a dyke-like ridge of cupriferous amygdaloid. The surface had not been stripped, but was covered with soil, forest loam, brush, tree roots and moss. There were, however, four or five outcrops along the ridge from the bottom of the slope up to an elevation of 100 ft. These lay in a line which, by the compass, had a bearing of N. E. and S. W., which is the strike of the deposit provided it be a vertical attitude; but this question cannot be determined till farther stripping and exploring has been done. If the deposit has a dip or hade, the true strike, which is of importance as a guide to further exploration, would have some other direction than N. E. and S. W. The outcrops show very clearly a width of at least 15 to 20 ft., though nowhere is the contact with the country rock exposed. The trap has a much more pronounced amygdaloidal structure at the base of the slope than higher up, but does not carry so much visible copper. The whole appearance is that of a dyke filling a fissure in the Animikie strata. Whether the amygdaloidal trap cuts the diabase trap cap which rests on the shales, cannot at present be determined. It probably does not.

There are, however, some circumstances which, in view of the meagerness of the exposures, render other explanations possible, and the conclusion that the formation is a dyke can only be held tentatively. These are (1) that at a level of 100 ft. up the slope there is a small outcrop of a fine-grained, brownish-red sandstone such as is common in the Keweenawan series, but which has nowhere been observed by the writer in the Animikie; (2) dykes do not usually present a highly vesicular or amygdaloidal structure which is rather the characteristic of surface flows; (3) the supposed dykes are much more vesicular and the vesicules are larger at the foot of the sloping line of outcrop than at the top, which is contrary to what we would expect with reference to the formation of vesicules in any molten mass of rock, the mass being usually more vesicular toward the top where the pressure is less. The other possible explanations, none of which are supported by any direct field evidence, are (1) that the supposed dyke may be a small piece which has been let down within the Animikie by faulting from the Nipigon, which may be supposed to have once covered the Animikie here as it does elsewhere; or (2) it may be the infilling of a fissure in the Animikie formation from above by a surface flow of vesicular lava which brought down with it portions of the Nipigon sandstone; or (3), least likely of all, it may be a small outlying patch of the Nipigon resting on the surface of a pre-existing slope of the Animikie.

A little exploration and mining would soon set at rest these questions as to the precise nature of the formation. We have this fact at least, that it is a rock of the same facies as the amygdaloids of the Keweenawan or Nipigon, similarly charged with copper, well within the Animikie slates and apparently cutting them. In this respect the formation differs from the amygdaloids of the Keweenawan which are interbedded and contemporaneous with the other rocks of that age, while the formation here discussed is apparently of later age than the Animikie, and may very probably be of Keweenawan age, though associated with Animikie rocks.

Character of the rock.—The rock in which the copper occurs is a fine-textured purplish-brown trap strongly amygdaloidal in some portions and only feebly so in others. The least amygdaloidal portions when examined in thin section prove to be typical diabase. Slender idiomorphic plagioclase crystals lie embedded in allotriomorphic masses of purplish to yellowish gray augite and in yellowish green masses of chlorite which is doubtless the result of the alteration of the augite. Yellowish brown iron oxide partly opaque and partly translucent occurs in profusely scattered grains.

The more amygdaloidal portions show in thin sections a finer texture but an equally strongly pronounced ophitic structure. Augite is not so abundant and plagioclase is the dominant mineral. A portion of the base appears to be glass, being colorless and isotrophic; and the augite is probably represented in part by the glass and in part by certain decomposition products interstitial between the feldspars. Magnetite and brown iron oxide are generally distributed. The crystals of plagioclase are arranged tangentially to the periphery of the amygdaloidal cavities. The latter are filled with calcite or dolomite and a brightly polarizing fibrous or lamellar mineral doubtless a zeolite. In the thin sections examined no copper was detected, but macroscopically it may be seen scattered through the rock in small grains which do not appear to fill up the round vesicles, but to be more irregular in shape.

The brown red sandstone above referred to is very fine textured and could not be identified as a sandstone with certainty in the field. In this section it is seen to consist of an aggregate of rounded, pear-shaped and angular grains of feldspar, pyroxene, chlorite and quartz, all the grains having a coating of iron oxide. A good deal of the secondary matrix appears to be feldspar, probably albite and orthoclase, and it is full of slender colorless needle-like microlites. Twinning lamellæ of the secondary feldspar are in some cases distinct, but for the most part are not apparent. Some of the rounded clastic grains of feldspar show feeble traces of secondary growth.

Proportion of Copper.—A few specimens of the rock were collected with the view of ascertaining its average value as a copper ore. Four of these have been submitted to Mr. F. L. Sperry, chemist to the Canadian Copper Co., at Sudbury, who has very kindly analyzed them. These specimens taken from different parts of the outcrop at an elevation of 64 feet above the foot of the slope, and one from the lowest outcrop gave the following percentages of copper:

Sample No. 1 64 feet level	1.32%	Copper.
" No. 2, lowest outcrop	0.27%	"
" No. 3, 64 feet level	2.88%	"
" No. 4, " " "	3.57%	"

Besides this occurrence the writer was also shown other specimens of amygdaloidal trap carrying native copper, which were said to come from the township of Crooks; but although the locality was carefully examined the deposit could not be found as the services of the guide who knew its whereabouts could not be secured. Later in the season Mr. Hille, mining engineer of Port Arthur, secured the necessary guide and proceeded to the place where these specimens were taken, and he has since informed the writer that he succeeded in locating a dyke-like formation of amygdaloidal trap carrying copper in Sec. 4, Con. II of Crooks. But enough has been advanced to show that the Animikie rocks of Thunder bay are worth careful prospecting for copper.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geology of the quicksilver deposits of the Pacific slope, with an atlas. By GEORGE F. BECKER. pp. xix and 486; with 7 plates, 20 figures in the text, and atlas of 14 sheets. (Monographs of the U. S. Geol. Survey, vol. XIII, 1888).

An earlier monograph of this survey by Mr. Becker treats of the geology of the Comstock lode and the Washoe district; and that investigation was a most useful preparation for the present work. Steamboat Springs, one of the most instructive localities of quicksilver mining described in this volume, is in the west edge of Nevada, only six miles northwest from the wonderfully rich Comstock lode, with which it has very close relationship in its geology and ore deposits. This locality lies close east of the great Sierra, but all the districts in California where quicksilver mining has been productive are in or near the Coast Ranges, separated from the Sierra Nevada by the Sacramento and San Joaquin valley. The comprehensive study of the probable origin and manner of formation of these quicksilver deposits has involved the consideration of much of the stratigraphic geology of western California, and that of its eastern part, including the Sierra, will doubtless be similarly examined in Mr. Becker's next monograph, on the Gold Belt of California, which work was entered upon immediately after the completion of this report.

During the thirty-six years from 1850 to 1885 inclusive, the world's product of quicksilver is estimated at 101,300,000 kilograms, or about 223,000,000 pounds, its estimated value being $146,800,000. The chief uses of this metal are for the amalgamation of ores and the manufacture of vermilion. As the process of amalgamation was discovered in Mexico more than three hundred years ago, and has ever since been extensively employed there in mining gold and silver, the Mexican government was led in 1873 to offer large bounties for the development of quicksilver mines. But the first discovery of the great quicksilver deposits of California was made so late as 1845, at New Almaden, which from 1850 to 1886 yielded 853,259 flasks of 76½ pounds avoirdupois. The total product of the California mines during the same period was 1,451,370 flasks, being about half of the total production of the world. The large ratio was much increased from 1875 to 1883 by the rapid mining of the Comstock lode, the extraction of its bullion being wholly by amalgamation.

All the quicksilver mines of the world and the principal known localities of its occurrence are described, the greatest mine being that of Almaden, in Spain. Its other most important mines are at Idria, Austria, in Tuscany, in Kwei-Chau, China, and in Huancavelica, Peru; but the Peruvian mines have not been worked during recent years. The proportion of California to other countries in the production of this metal since 1850 is not likely to be maintained; for Almaden, Idria, and Kwei-Chau have far greater amounts of ore in sight, although the Almaden mines have been worked since 415 B. C. In Europe and Asia these deposits bear a relation to the great mountain belt stretching from the Pyrenees and Alps east to the Himalayas, called by Mr. Becker the Alpimalayan chain similar to the relation of the American deposits to the Cordilleran belt that forms the Pacific border of the whole western continent.

Cinnabar is everywhere the principal ore of quicksilver, and it is in most cases demonstrable that its deposition was subsequent to some disturbance of the country rock. In the quicksilver mines of California the usual mineral association consists of cinnabar and traces of native mercury, with pyrite and marcasite, silica and carbonates; but sulphur occurs at three mines, chalcopyrite is not very uncommon, stibnite is found rarely, gold or auriferous pyrite occurs in a few cases, millerite in a number of instances, and barite in one. A new bitumen, two new chromium minerals, and a red antimony sulphide have been detected with cinnabar in this investigation. The cinnabar occurs in the form of veins, sometimes cutting sedimentary rocks and sometimes following the stratification. Connected with the veins are also recticulated masses and chambers of the ore, and adjoining porous sandstone is often impregnated with it.

The country rock of the cinnabar deposits of the Pacific slope is of the most varied character, ranging from granite, probably Archæan, at the Steamboat Springs to modern lake beds and recent lava at Sulphur

Bank. The one occurs in every variety of the early Cretaceous (Neocomian) rocks, including unaltered sandstones, and metamorphic phthanite, pseudo-diabase, pseudo-diorite, glaucophane schists, and serpentine. The most important deposits are found in the metamorphosed rocks, but this seems to be due only to their hardness. Chico sandstones, the uppermost Cretaceous formation of California, contain cinnabar at New Idria. Elsewhere this ore is found in sandstones that are believed to be Miocene, in Pliocene and post-Pliocene andesite, and in recent basalt.

Great similarity of all these quicksilver deposits indicates that they were not derived from the enclosing diverse rock formations, and that they have had a common history, which in two places has been continued to the present time. The process of deposition of cinnabar from heated waters holding soluble double sulphides, issuing from great depths, is still going forward at Steamboat Springs and Sulphur Bank, where, as well as in the laboratory, Mr. Becker has carefully studied the chemical conditions of the solution and precipitation of this ore. He concludes that the enclosing rocks have been without effect upon the deposits, since they occur in nearly all the rocks of the Coast Ranges. The origin of the quicksilver is shown to be probably by leaching from the underlying granite, which the author believes to be the first-formed crust of the globe, still in many places exposed to view and forming its surface.

Deposition of cinnabar appears to have taken place through the agency of hot sulphur springs, which were probably in all cases of volcanic origin. Basalt of Quaternary age is the lava usually associated with the deposits; but at New Almaden it is a rhyolite dike, which is probably Quaternary or late Pliocene. The author shows that after the close of the Jurassic no eruptions seem to have taken place in the Coast Ranges until the close of the Miocene or a little later. Andesites were then ejected at intervals until the close of the Pliocene. Younger andesites, which seem to be early Quaternary, constitute a natural group of trachyte-like rocks, for which the name *asperites* is proposed in this report. These form Mt. Shasta and the surrounding country, and are extensively developed at Clear lake thence southward to the bay of San Francisco, and at Steamboat Springs. Still later, during the Quaternary and down to very recent times there have been many basalt eruptions. The date of the latest in the vicinity of Sulphur Bank was probably within a thousand years or less; and in northern California there is good reason for believing that there has been a small basaltic eruption within forty years. From these records of volcanic activity it appears that the age of the cinnabar deposits is limited to post-Miocene time, and there is little doubt that nearly all the ore has been deposited since the end of the Pliocene.

On new plants from the Erian and Carboniferous, and on the characters and affinities of palæozoic gymnosperms. By SIR J. WILLIAM DAWSON, LL.D., F.R.S., F.G.S., &c. (From the Canadian Record of Science, January, 1890). This paper is based on some fossil plants found by Mr. R. D. Lacoe in Meshoppen, Wyoming county, Pa. It describes Dictyo-cordaites lacoi, and Tylodendron baini. The author unites and compares fragmentary material from different places, published under different names, arriving at some condensed statements of the affinities of palæozoic gymnosperms which tend toward the further elucidation of the history of vegetable life. He concludes as follows:

1. That the nearest structural affinities of the palæozoic gymnosperms with the higher cryptogams lead toward all the groups of acrogens, viz: Sigillariæ, Calamiteæ, Lepidodendreæ, and Ferns.

2 That the present dominant groups of Coniferæ proper and Cycadaceæ are absent or slenderly represented in the palæozoic.

3. That the dominant palæozoic families are the Nœggerathiæ, Cordaiteæ and Taxineæ, and that these occupied a prominent and important place, and culminated in the palæozoic and early Mesozoic periods.

4. The two former families, did they now exist, would supply connecting links between the Coniferæ and Cycadeæ, and between the latter and the Acrogens.

Prof. O. C. Marsh contributes to the *London Geological Magazine for January* a description of one of the new reptilian forms recently announced by him from the Cretaceous strata of the western states. Prof. Marsh has enriched the American fossil vertebrate fauna with many strange forms of extinct life, but probably none of them surpasses or perhaps equals this. Of all the reptiles that marked the Mesozoic age the group to which this fossil belongs is one of the most peculiar. The Ceratopsidæ, or horned family, show us the possibilities of variation in a most remarkable manner. It seems as if nature at the moment when the scepter was passing away forever from the type of vertebrates had undertaken to try her hand at producing a more monstrous and *bizarre* combination of characters than the age had ever seen. The last reptile sovereign of the Mesozoic empire was at the same time a summary of its ancestors and a prophecy of its successors.

In the very highest of the Cretaceous strata of Wyoming and Montana, "fresh water or brackish deposits which form a part of the so-called Laramie," are found the fossils from which Prof. Marsh has constructed the genus Ceratops, as the type of the family. His paper in the Geological M[illegible]zine describes the genus Triceratops by the species *T. flabellatus,* [illegible] *horridus*. The skull of this genus is the largest known among lan[illegible]s recent and extinct. In the former species it measures six feet and in the latter eight feet in length. Seen from above it reminds one strongly, in general shape of the head, of a bird, being round behind and tapering to a sharp point in front. A side view suggests at the front the profile of a rhinoceros, by the massive nasal bones and the thick short tubercle, representing the "horn" of that animal. At the back the large rounded orbit and the two long horn-cores growing from the frontal bones strongly recall the head of the ox. In most skulls the fore maxillary bones occupy the front place, but here Prof. Marsh describes one anterior to those, which he calls the "rostral" bone. A corresponding bone in front of the symphysis of the lower maxillaries is called the "dentary" bone. It is not quite clear from Prof. Marsh's paper whether or not these bones exhibit the true osseous tissue. He calls them dermal ossifications and says that they were covered by strong horny beaks like those of birds. In addition to these extravagances of nature in this singular genus of reptiles, the hinder part of the head is covered with enormously expanded parietal and squamosal bones all four of which meet the frontals and are bordered behind and outwardly by a row of small ossicles, "epoccipital bones," like tubercles or blunt spines which, says Prof. Marsh, had horny coverings and in old animals were coössified with the adjoining plates.

Prof. Marsh adds that these stray fossils characterize a distinct horizon in the so-called Laramie group of the Upper Cretaceous, which may be traced for 800 miles along the Rocky mountains.

Mr. Howorth contributes a paper to the same journal on the question, "Did the great Siberian rivers flow southward in the Mammoth age?" He shows that the whole area of northern Asia has long been slowly rising and thus tending toward a state of things that prevailed in the past. He shows that no great amount of elevation would be necessary to prevent the northern flow of the Obi and the Yenessei, their upper reaches being now only 200 or 300 feet above the sea, so that an elevation of from 40 to 50 fathoms would suffice to reverse the drainage of this region.

The structure of the Asiatic continent requires as a corollary from this conclusion that a vast Mediterranean sea must have existed there, and of this Mr. Howorth offers the following evidence:

1. The scattered lakes over this part of Asia are inhabited by the same animals.
2. The intervening stretches of desert contain semi-fossil shells of the species still living in the lakes.

As a further argument Mr. Howorth points out that it has been a difficulty with geologists to understand how the great sea which once certainly filled the Aralo-Caspian depression was supplied with water. This difficulty he removes by the theory advanced in his paper.

Mr. Howorth further remarks that the great rivers of European Russia still flow southward and that what he here maintains regarding the Obi and the Yenessei was also true of the Lena. It concludes by calling attention to the influence which such a change in the physical geography must have had on the climate by rendering it milder and more capable of supporting the fauna whose remains are now found in the Tundras of Siberia.

It is an obvious inference from Mr. Howorth's premises that northern Asia is rapidly tending back to the former state and that in an ag geologically not distant we may expect to see the course of these great rivers reversed and a Mediasian sea occupying southern Siberia.

Untersuchungen ueber Gesteine und Mineralien aus West Indien, von J. H. KLOOS. (Samml. d. Geol. Reichs-Mus. in Leiden, 1889, p. 169). The former part of this work was noticed in the GEOLOGIST on p. 61, vol. I. The rocks described in this part are from Dutch Guiana, and constitute a part of the collection which was made by professor Martin and deposited in the Leiden museum. The molluscan fauna was described and illustrated in the former part by Dr. J. Lorié and M. M. Schepman, and indicate a late Tertiary age for the fossiliferous rocks. Mr. Kloos gives detailed microscopic descriptions of the massive rocks, including augite-audesyte, granite (containing augite), diabase (and amphibolyte), crystalline schists, chlorite schist and a peculiar veined and schistose rock having a porphyritic structure; also uralitic schist and hornblende gneiss. The work is illustrated by eighteen figures of microscopic thin sections.

A catalogue of North American Palæozoic crustacea confined to the non-trilobitic genera and species. By ANTHONY W. VOGDES. Author's edition. (From the Annals of the New York Academy of Sciences, vol. V, No. 1, 1889). The list is annotated, and shows a careful and laborious search in American literature. Some of the genera are figured, and nearly all have author's diagnosis republished from the original descriptions.

Note on the discovery of Trilobites in the Neobolus beds of the Salt-Range. By WILLIAM KING. (Records of the Geological Survey of India; Vol. XXII, Part 3, 1889, pp. 153-157.) The importance of the discovery of trilobites in the *Neobolus beds* of India can hardly be overestimated. These beds have been the subject of considerable controversy among Indian geologists; the beds being variously called Permian, Lower Carboniferous and Silurian. The discovery of trilobites, which Dr. Waagen, the palaeontologist, says undoubtedly belong to *Conocephalidæ* and *Olenidæ*, at last proves the true position of these beds which must now fall even below the Silurian to "the upper region of the Lower Cambrian." One specimen, according to Dr. Waagen, is very nearly related to *Conocephalites formosus* Hartt. This remarkable discovery is expected to be fully treated in the forthcoming parts of Vol. IV of the Salt-Range fossils and we shall wait with much interest the publication of these results.*

Elemente der Palæontologie. By GUSTAV STEINMANN and LUDWIG DŒDERLEIN. Part I, pp. 1-336, 1889. Part II, pp, 337-848, 1890. W. Engleman, Leipzig. This work is on a plan similar to Zittel's masterwork "Handbuch der Palæontologie;" the classification differs somewhat and the work is not so profusely illustrated as Zittel's, there being 609 figures of invertebrates as against 1,667 figures in Zittel; the latter work also containing almost twice as many pages as the former. The work on the whole will form a good substitute for Zittel to those who do not want very comprehensive information on the subject, otherwise there is no substitute for Zittel, nor do the authors make any such claim.

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*Compan AMERICAN GEOLOGIST, vol IV, p. 60.

Devonian Plants from Ohio. By DR. J. S. NEWBERRY. (From the Journal of the Cincinnati Society of Natural History, Vol. xii, 1889, pp. 48-56, plates 4-6.)

This paper gives some additional information about the paleobotany of the Corniferous limestone of Ohio, a formation which has contributed but little to this science. Five species are figured and described, four of which are from the Delaware limestone or upper division of the Corniferous. The remaining species, *Dadoxylon newberryi* Dn., occur in the Huron shale, and according to Prof. Orton (Rep't Geol. Surv. Ohio, vol. vi, p. 30) is found free in the shale and, also, at the centre of concretious. It is interesting to note that in New York state the Genesee shale, which is at about the same geological horizon as the lower Huron shale, contains so-called Coniferous wood, which Sir William Dawson has named *Dadoxylon clarkii*. This species of Dadoxylon is not rare in a concretionary layer of the Genesee shale on Canandaigua lake and at other localities in Ontario county, New York.

One of the four Corniferous species, *Sphenophyllum vetustum*, is new and, except *S. primævum* Lx. from the Hudson river group of Kentucky and Ohio, it is the most ancient species of this genus yet found in America. The early occurence in the Corniferous limestone of *Lepidodendron gaspianum* Dn., or a closely allied species, which was reported provisionally in 1873 (Rep't Geol. Surv. Ohio, vol i, part i Geology, p. 147), is confirmed. The tree ferns *Caulopteris antiqua* Newb. and *C. peregrina* Newb. were first figured and described by Sir William Dawson in the Quart. Jour. Geol. Soc., vol. xxvii, 1871, pp. 271-272. On p. 269 it is stated that Dr. Newberry had named the specimens but allowed Dawson to compare them with the other species described in the paper. In the Ohio geological report for 1873 (*loc. cit.* p. 146), Dr. Newberry mentions these species but without figures or description and it appears that his description has been delayed until the present paper, which is eighteen years later than Dawson's.

Dr. Newberry's statement that "the fossil plants from New York described by Dawson, Hall and Vanuxem are from the Chemung or Catskill" is somewhat erronous. It is true that in part they are from these formations, but the Hamilton period has furnished a considerable number of species. The number of species known from the New York Devonian is approximately as follows: The Corniferous limestone has *Protosalvinia huronensis* Dn. and the doubtful form called *Spirophyton candagalli* (Van.) Hall; the Macellus shale, six; Hamilton, nineteen; Genesee, nine; Portage, six; Chemung, twenty-four; and the Catskill, five.

The material of this paper was prepared originally for a part of vol. iii, of the Palæontology of Ohio, but unfortunately was not published by the State. There are drawings and descriptions of new species of

Coal Measure plants, yet unpublished, which the author hopes to make the subject of another memoir. A portion of the specimens upon which the present paper is based may be seen in the Columbia College Museum in New York.

Economic geological survey in Georgia and Alabama throughout the belt traversed by the Macon and Birmingham railway. By J. W. SPENCER. 86 pp, 8vo, with a geological map. Athens, Ga. This is a neat, concise and thorough geological description of the area designated, in non-technical language. The report mentions a fault at the Henryellen coal mine, where the direct slipping of the earth's crust has brought the Knox dolomyte and the Coal Measures sharply side by side, the fault amounting to 9,000 feet. The Clinton iron ores, the cause of the growth of Birmingham, and the basis of the late increase in iron manufacture in Tennessee, Alabama and Georgia, are fully described, and several page-plates in half-tone from photographs give much aid in understanding the features of the country as described. The brown iron ores and the coal fields are fully described, also the gold belt of Georgia. Graphite, asbestos, corundum and tin are enumerated among the economic minerals. Soils and water-powers are noted and some of the latter illustrated. It would be well if all the southern railways had a similar survey and publication.

CORRESPONDENCE.

DR. DAVID HONEYMAN. Dr. Honeyman was born at Corbier Hill, Fifeshire, Scotland, in 1817, and died at Halifax, Nova Scotia, on the 17th of October, 1889. He received his education at the University of St. Andrews. Having selected the church as a profession, he studied first at Glasgow and afterwards at Edinburgh. In 1836 he entered the United Secession Theological Hall, was licensed in 1841, and joined the Free Church immediately after the Disruption. Honeyman was appointed professor of Hebrew in the Free Church College of Halifax in 1846, and after that time he made his home in America, being successively minister of the Presbyterian congregation of Schubenacadie, afterward of Antigonish, and finally in 1862 he resigned the ministry, and devoted himself wholly to scientific work. During his stay at Antigonish he made an excellent geological memoir on that part of Nova Scotia, which he published in 1865, in the *Proceedings and Transactions of the Nova Scotian Institute of Natural Science*, vol. I, Part IV, p. 105. In 1862 he was appointed superintendent of the Nova Scotian section of the London International Exhibiton; and also at the Paris exhibition of 1867. During his stay in Paris his knowledge of the geology of Nova Scotia attracted the attention of Barrande and de Verneuil, both of whom esteemed very highly his observations on the Palæozoic rocks and fossils. From that date, Barrande "never forgot me in the distribution of his very interesting and valuable publications," as Honeyman writes in one of his letters, dated Oct. 16th, 1884, adding: "I received your volume on *The Taconic system*, with the interesting correspondence. I read Barrande's letters very carefully. Certainly Logan and the other adversaries of the Taconic do not make a very creditable appearance in the correspondence." * * * "E. de Verneuil is gone, Barrande is also gone, and only Marcou is left of all my intimate friends of 1867. I am very glad to find that my very good friend Marcou still retains his pristine vigor and that his pen is always ready to defend his own and others' rights. Long may he continue in vigor of body and mind."

Dr. Honeyman was an original and very careful observer; and he defended successfully all his researches in the field of Nova Scotian geology and his rights whenever attacked, as was the case in his controversy with Sir J. William Dawson. He published thirty-nine papers on the geology of Acadia, particularly on Arisaig, Antigonish, the gold-bearing series of Yarmouth, and the glacial action and transportation in Nova Scotia. All his communications were made before the Nova Scotian Institute and published in its transactions, contributing largely to the reputation of that institute as well in the Canada Dominion as abroad.

Honeyman's sphere of action was not limited to geology and mineralogy; he extended his studies to biological subjects. Eight of his papers treat of new and rare fishes, echinoderms, sponges and organisms found attached to sub-marine cables. He represented Nova Scotia at the London Fisheries Exhibition of 1883, as well as at the Dublin Exhibition of 1865 and at the Philadelphia Centennial Exhibition of 1876. Appointed curator of the Provincial Museum of Nova Scotia, he was so successful in his management, that he is justly considered as the creator of it, at least to a large extent; for the museum, under his charge, has acquired such dimensions as to demand a special building for the display of its collections. Dr. Honeyman received the honorary degree of D.C.L. from King's College, Windsor. He was a member of the Geological Society of France, a fellow of the Geological Societies of London and of America, and of the Royal Society of Canada.

J. M.

PREGLACIAL CHANNELS AT THE FALLS OF THE OHIO. In a previous letter I referred to what seemed to be evidence of a terminal moraine near Louisville, Ky. Subsequent observation has confirmed this opinion, although there are many perplexing problems yet to be solved connected with the drift in this locality.

A residence of five years in Louisville with daily opportunities for observation has impressed upon the mind of the writer, as never before, the fact that very little erosion has taken place in post-glacial times. It has also been made evident that very little scraping out was done by the glacier, but a good deal of filling in, especially toward the southern limit of the ice-sheet. It is well known to geologists that the Ohio falls at Louisville have only been in existence since the ice age. The old channel of the Ohio river is supposed to have been south of its present bed where the city of Louisville now stands. While this may be true, perhaps, of one branch of it, yet another channel, as we will notice, has been discovered on the north side of the river in Indiana. The plain, upon which the city of Louisville is built, is chiefly a filled-in pre-glacial valley formed by the Beargrass and other tributaries that joined the Ohio at this place. Many of the smaller streams were entirely cut off during the melting of the ice-sheet, and the two branches of the Beargrass, still in existence, are only relics of their former greatness, their mouths having been filled in to a very great extent. At the mouth of the East branch, at one of the distilleries, a well was sunk to the depth of four hundred feet without coming to rock; yet near it, the present stream flows over limestone rock that comes very near the surface. At the mouth of the west branch of the Beargrass a sewer is being constructed to connect with it. For the distance of over half a mile, right in face of the ridge or terrace, no rock was reached at a depth of twenty-five feet, showing that the ancient valley must have been this wide. The present stream is very narrow—not more than thirty feet wide—and as it breaks through the ridge it flows eastward, seemingly *up* hill, for evidence of an old channel is seen running to the west where it must have connected with the Ohio river in preglacial times, below, not above the falls, as at present. The valleys of the Beargrass opened into the wider valley of the Ohio where a meeting of the waters takes place. The old channels running through this valley or plain can still be traced through the city of Louisville and vicinity by the numerous depressions between the river and the ridges. About six miles above the falls the Ohio river seems to have parted in early times, as here the valley begins to open out on both sides of the present stream. One arm, if not several, came down on the Kentucky side, another stretches out around the city of Jeffersonville, Ind., and can be traced by a line of swampy depressions at the base of what is known as Walnut ridge, very much like the preglacial channel of the Mississippi river at Minneapolis and vicinity. This Indiana branch or old preglacial river, leaving the present channel of the Ohio below Utica, curved to the left—as we look up the stream—and, bending southward again, it joined the Kentucky branch below the falls.

The Indiana survey, 1874, page 176 in speaking of this region says:—"In the gravel or altered drift of this region are found mastodon remains at as great a depth as thirty feet, which seems to indicate the situation of an old river or lake bed."

The United States depot of supplies stands near the south margin of this depression, and the well for the engine-house is forty-four feet in depth, going through strata of clay, sand and gravel—coarse hard gravel overlying the rock to the depth of about six feet. The depression seems to deepen towards the north as there is a difference of over ten feet between the south and north parts of the same building enclosure. No doubt this preglacial channel was uniform in depth to the old bed of the Ohio—about one hundred and fifty feet deeper than at present. Both on the Kentucky and Indiana sides of the river there are several depressions and raised beaches, and after the parting above the falls it would be difficult to determine which was the main channel of the preglacial Ohio. Probably the largest branch was on the Kentucky side, although the Indiana valley is the most extensive. This much is certain, however, that the site of the falls in preglacial times was an island, and must have stood up more than a hundred feet above the level of the surrounding waters, for as we have seen, the old channels are filled in at least one hundred and fifty feet. This island, covered doubtless with a luxuriant vegetation, the wide, preglacial valleys and countless streams, must have formed a picture beautiful to behold. On the Indiana side of the falls the old and new channels come very close together, so close in places that only a bank of clay or a thin edge of rock separates them. In fact, there are places over the falls where the present current of the river runs in an old preglacial channel, making the bed of the present stream much deeper in some places than others, but for the most part the falls of the Ohio at Louisville consist merely of a shallow channel worn in the surface of the preglacial island already referred to.

The old channels being filled in with glacial *debris* the river was forced into its present course. The amount of post-glacial erosion has been very slight as the present channel does not admit of the passage of vessels of the lightest draft except at very high water; therefore a canal had to be constructed to avoid the falls and permit navigation. From personal observation the writer, as already intimated, is convinced that most of the rock erosion took place, not during nor since the ice age, but in preglacial times.

Louisville, Ky., Feb. 8, 1890. JOHN BRYSON.

MR. H. T. CRESSON AND THE DELAWARE RIVER DWELLINGS. A general impression has been held for the last two years that there were river dwellings on the Atlantic coast. This impression was gained from a letter which was published in the *American Antiquarian* for November, 1887, entitled "River dwellings on the mud flats of the Delaware river." This letter was written by Mr. H. T. Cresson, and was published exactly as it was written, title and all. The letter was quoted by Mr. H. W. Haynes in the "Narrative and Critical History," with the addition of a sentence stating that he, (Mr. Cresson) has also kindly sent to the writer (Prof. Haynes) a small illustrative collection from each site for his study." Mr. Cresson, after two years time, seeks to withdraw from his position about "river dwellings," but in order to do so furnishes to *Science* a letter which he pretends is a copy of the one sent November, 1887. There are several discrepancies between the two letters, which, if you will allow me, I would be glad to set before your readers. They are as follows:

In *Science* Feb. 14, page 116, paragraph 4, this sentence is inserted: "More mature deliberation, based upon hand dredging and excavation made since my first visit (1870) only serves to confirm my opinion that they were fish-weirs." No such sentence was written in 1887. On the same page, fifth paragraph, there is the following: "The results so far seem to indicate that the ends of piles embedded in the mud, judging from the implements and other débris scattered around them, had once served as supports to structures intended for fish-weirs. These in all probability projecting a few feet above the water, and were no doubt interlaced with wattles or vines to more readily bar the passage of fish into the river." In 1887 this sentence read as follows: "The results so far seem to indicate that the ends of the piles embedded in the mud, judging from the implements scattered around them, once supported shelters of early man, that were erected a few feet above the water, the upper portions of the piles having disappeared in the long lapse of time that must have ensued since they were placed there." Notice the phraseology: "Three different dwellings have been located, all that exist in the flats referred to." In *Science* it is, "Three different stations were located, probably all that exist in the bed of the creek referred to." In the same paragraph a sentence reads as follows, "The implements found in one of the stations are generally made of argillite, with a few of quartz and quartzite. Some were very rude in character, not unlike the paleoliths found by Dr. C. C. Abbott in the Trenton gravels." In 1887 the sentence read, "The implements found in two of the supposed river dwelling sites are very rude in type, and are genarally made of dense argillite, not unlike the paleoliths found by my friend Dr. C. C. Abbott in the Trenton gravels." The next sentence reads in *Science*, "Objects of stone and pottery, rather better in finish than those at station A, have been found at the other stations, B and C." This read in 1887, "The character of the implements from the other and third supposed river dwelling on the Delaware marshes, indicating a greater antiquity than ordinary surface-found Indian relics."

The phraseology of these paragraphs and sentences is peculiar. Each sentence in the original letter, written in 1887 gives the impression that Mr. Cresson had certainly found piles which he thought once supported river dwellings. The sentences furnished to *Science* in Feb. 1890, give the impression that these piles were fish-weirs. Mr. Cresson is unwilling to bear the responsibility of his own statements, made two years and more ago, and charges the editor with "garbling," whereas the "atrocious garbling" is done by himself in 1890. The letter has stood in the *Antiquarian*, and no request for correction has been made. He says now, "I hope this letter, (the one in *Science*) giving a brief resume of the finds at Naaman's creek mouth will cause all absurd romancing in regard to pile dwellers on the Delaware to cease. If they ever did exist I have certainly failed to find any traces of such a people, and never upheld any such nonsensical theories."

The nonsensical theory appeared over Mr. Cresson's name, and stood for two years and three months. Perhaps your readers can reconcile these statements. The pile dwellings are evidently fish-weirs. They may have been made by Indians and they may not. The reliability of the person describing them is exceedingly doubtful.

Respectfully yours,

Mendon, Ills., Feb. 19, 1890. STEPHEN D. PEET.

THE LEVEL OF NO STRAIN.—Students of geology must thank professor Claypole for his simple presentation of the question now so actively discussed by certain English physical geologists regarding the "Level of no Strain" within the earth. Teachers should also be interested in it, for if the discussion lead to a valid conclusion, the Contractional Hypothesis that is so generally taught to their classes, ought to be abandoned, except in teaching the history of geology. But is not their conclusion—namely, that the depth of the level of no strain is only ten or twelve miles below the surface—only a special solution of the problem of a cooling body? It rests, as professor Claypole shows clearly, on the absence of cooling below a depth of 400 miles, and this in turn rests on the postulate that the temperature of the earth was once uniform from surface to center. Why should a highly specialized initial distribution of internal temperature be accepted as the only one worthy of discussion? I have sometimes wondered if it were not chosen on account of its simplicity; but certainly there are other conceivable and admissable initial distributions that deserve consideration.

The uniform distribution of temperature rests on the supposition of convectional movements by which all previous inequalities of temperature were equalized. It is very questionable whether such movement could continue until anything like equality of temperature was attained; viscosity and friction would exceed the relatively small gravitative forces, on which the latter stages of convection must depend, long before equality of temperature within and without was reached.

Moreover, an essential of the postulate of uniform initial distribution of temperature is a sub-postulate of uniform distribution of specific gravities, and this is altogether unlikely. The whole contractional hypothesis, with its various postulates, rests in turn on the nebular hypothesis, in which there is nothing to forbid and everything to suggest that the nuclei of the planetary masses were denser than the subsequent external accretions; and if we postulate such an origin for the mass of the earth the possibility of the convectional equalization of central and superficial temperature is entirely excluded. An enormous excess of temperature might remain about the center without causing sufficient expansion of the dense material there to produce convectional unstability. A crust would form and geological operations would proceed in their recognized order while a vast store of heat remained imprisoned within; and the level of no strain at the present stage of the history of such an earth, would be much deeper

than in the ideally simple earth that has been generally discussed. An external shell of 400 miles thickness would not then measure nearly the whole depth to which cooling would penetrate; conduction and contraction would be operative nearly from the center to the surface. According to one or another of the various admissable postulates as to the distribution of internal temperature at the time when the permanent external cause was found, the amount of surface contraction and the depth of the level of no strain will vary. While the physical studies of Read, Davison and others in this direction are of great importance, it is well that students should bear in mind the fact that their conclusions refer to *an* earth, but not necessarily to *the* earth.

Harvard College, Feb., 1890. W. M. DAVIS.

PERSONAL AND SCIENTIFIC NEWS.

THE SOUTH AFRICAN GOLD FIELDS. The rush of population to the new gold fields in south Africa still continues. The central town of the district, Johannesburg, has sprung up like a mushroom from nothing two years ago to a population of 20,000. Land then almost worthless has increased in value so that central lots are selling at £2,500 an acre, while those in the suburbs bring £500. The matrix of the gold is all quartz, so that crushing is the only means of obtaining the metal. No alluvial washings exist. This places the new region and town in a very substantial position. Speculation is less uncertain. Capital is required and is fast flowing in. The reef is said to extend for 100 miles in length and to have considerable breadth. Johannesburg is nearly 2,000 miles from the cape of Good Hope and bids fair to become the centre of a large English community, though not at present within British territory.

The gold-bearing deposit consists of conglomerates, a very unusual matrix for gold, though occurring also in Nova Scotia, where, however the yield is small. The strike of the reef, which is double, is nearly east and west, and its dip varies from 45° to 80°.

MUD ERUPTION IN ASIA. A remarkable eruption took place on Aug. 2, 1889, about 40 miles from Erzeroum in Asia Minor. The side of the mountain burst open and the village of Kantzorik, with 136 of its inhabitants was buried in a torrent of mud flowing from the gap. The flood was about five miles long by 300 yards wide, and the solid content has been estimated at between 50,000,000 and 60,000,000 cubic yards. It dried and hardened on the top but remained liquid below. The surface became deeply crevassed as is that of a glacier. Fine dust caused by the fall of masses of rock caused a rumor that a volcanic eruption had taken place, but there is no evidence of anything of this kind. It was in effect a land slip on a vast scale. The district consists of Mesozoic rocks cut and pierced by granite and basalt, and the catastrophe was probably due to the softening of some of the beds of the former and the pressure of an overlying mass upon the softened stratum.

DISCOVERY OF PHOSPHATE IN FLORIDA. Great excitement prevails in Citrus Co., Fla., and adjoining parts of the state, over recent discoveries of phosphatic deposit apparently in large quantity. The district lies along the Wekiva and Withlacoochee river and covers many thousand acres, being 100 miles in length and 12 to 20 in breadth. The phosphate is found at varying depths from one foot to sixty and occurs for the most part in "pockets" sometimes 100 acres in extent surrounded by "barren ground." It is soft, and seldom requires drilling or blasting. Regarding its quality, reports are conflicting; some giving it as very high in grade, 50 to 90 per cent. of phosphate and averaging 75. These figures are of course above the truth. South Carolina phosphatic material averages about 50, and it is not likely that this will be of better quality. The Canadian apatite does not exceed the higher figures, and this is much purer than any of the phosphatic marls. If worked with skill and judgment these beds ought to yield a good harvest to their owners as the market for phosphate is steady, and yearly increasing in extent.

SCIENTIFIC EXPEDITION TO YUCATAN AND MEXICO. Prof. Angelo Heilprin, of the Academy of Natural Sciences of Philadelphia and a party of specialists left New York on February 15th for Progreso, Yucatan, from which point they will begin an extensive examination into the geology, botany, and zoology of this little known country. After spending several months in the interior of this portion of Mexico, the party will embark for Vera Cruz to investigate the "*tierra caliente*" and the volcanic belt, Orizaba and Colima receiving especial attention. The party will then proceed to the city of Mexico, where the lakes on the plateau around the city will be studied. The expedition was organized under the auspices of the Academy of Natural Sciences of Philadelphia. The specialists connected with the expedition are (in addition to the director, Prof. Heilprin) Mr. J. E. Ives, marine zoology, Mr. Witmer Stone, botany and ornithology, Mr. F. C. Baker, conchology and general zoology and Mr. R. LeBoutillier, photography. The results of this expedition into a country geologically almost unknown will be awaited with great interest. The party is expected to arrive home before midsummer.

AT THE UNIVERSITY OF ALABAMA the department of chemistry and geology has been divided, geology and mineralogy being united under Prof. Eugene A. Smith, and a new professorship, that of chemistry and metallurgy, being created. This much desired enlargement will afford professor Smith more time to devote to the geological survey of the state, and with additional instruction in engineering, which has also been ordered by the trustees, will afford a good course in mining engineering and metallurgy.

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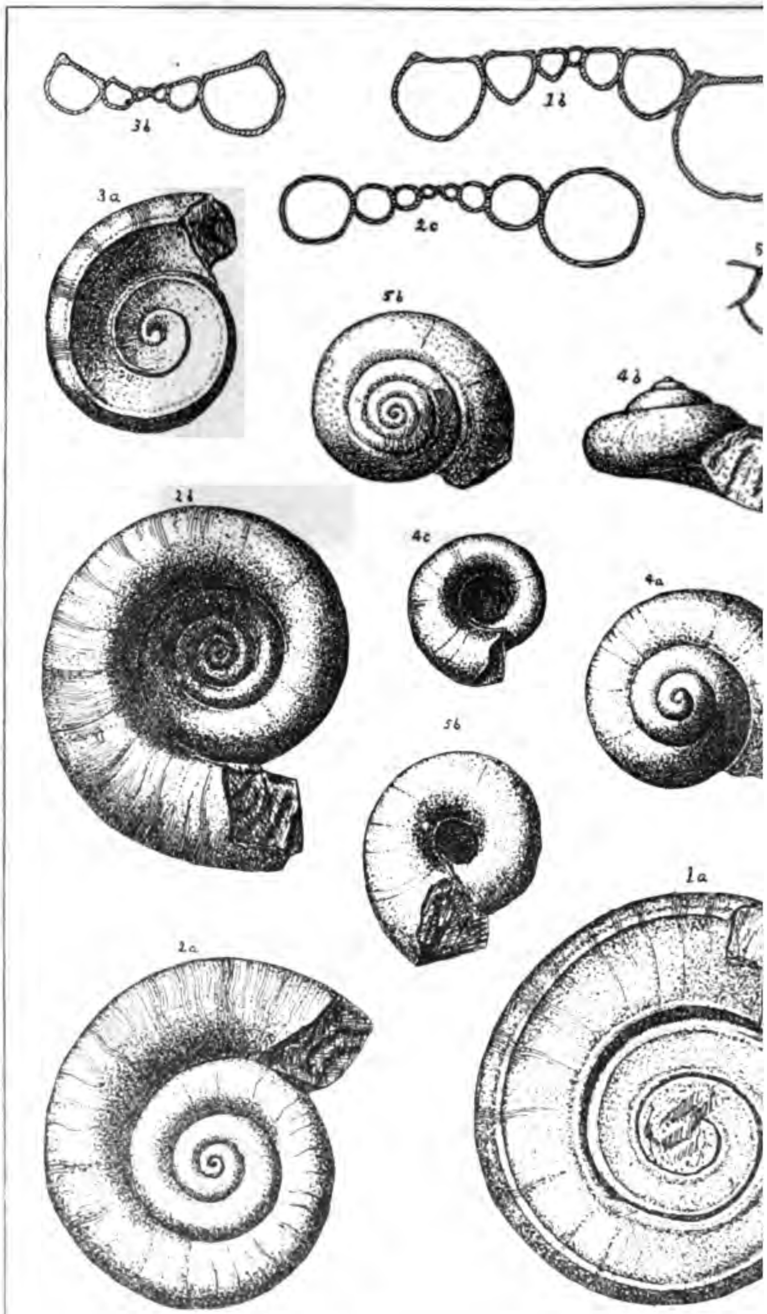

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CERTAIN FORMS OF STRAPAROLLUS FROM SOUTHEASTERN IOWA.

By CHARLES R. KEYES.

In the consideration of the generic characters of Straparollus certain forms from the lower Carboniferous rocks of southeastern Iowa present some interesting phases which illustrate fully peculiarities formerly regarded of great importance in the separation of this genus from Euomphalus. The two terms are of common occurrence in the literature of American Palæontology, and have been applied indifferently both to planorbiform gasteropod shells having angulated whorls and those possessing rounded volutions. The latter features were originally regarded as distinctive. Yet the multiplicity of forms manifestly belonging to the group founded by Montfort has given rise to the establishment of a number of genera which can now be considered only as of little or no utility and seem best disposed of when placed in the synonymy of this genus. Aside from the two leading sections, however, these various terms require no further reference here.

The species from the immediate vicinity of Burlington that have been referred to the two groups in question elucidate somewhat the true relations existing between Straparollus and Euomphalus, both as regards the structure of the shells and the probable optimum station of the animals when living.

Of more than fifty species of gasteropods described from the locality under consideration few have ever been figured; and consequently much confusion has arisen regarding the proper identity of many of the forms. Recently, however, a very complete series was obtained. The majority of the species comprising this collection have been treated elsewhere[1] with considerable detail and it remains now to consider more fully the forms of one of the most characteristic genera—Straparollus.

The generic relations of Straparollus and Euomphalus have long been a subject of controversy. And, while the question can not at present be regarded as definitely settled, the evidence derived from all available sources points to the co-extension of the two genera. Each name was primarily proposed for a group seemingly quite distinct. But later inquiry has indicated that the alleged generic distinctions are actually more apparent than real; and that the two sections can, with great propriety, be considered under a single term. Some recent writers have even proposed to make the two genera in question identical with Solarium established by Lamarck[2] for a group of modern gasteropods. But it does not appear feasible, nor advisable, to extend the limits of the Lamarckian genus as thus suggested; while practically the separation of the recent and ancient forms is not difficult and, as a matter of fact, is very convenient to the systematist.

Straparollus, as defined by Montfort,[3] has for its type *S. dionysii* Mont.—a form with the spire somewhat elevated, the umbilicus broad and shallow, and the whorls regularly rounded. Euomphalus of Sowerby,[4] represented by *E. pentangularis* Sow., includes planorbiform shells having more or less distinctly angulated volutions. With the types alone under consideration the two groups might appear sufficiently well marked to warrant their generic separation. A more extended comparison, however, of the described species reveals no reliable criteria by which the two groups may be distinguished. A further consideration of these resemblances and differences of divers individuals shows that they are so variable and that the gradations are so complete that the generic limitations heretofore usually assigned are clearly untenable.

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[1] Keyes: Proc. Acad. Nat. Sci. Phila., 1889, pp. 284-298.
[2] Syst. Anim. sans Vert., 1801.
[3] Conch. Syst., vol. II, 1810.
[4] Min. Conch., vol. I, 1814.

Briefly stated the general characters of Straparollus are: Shell rather thick, planorbiform, or depressed conical, broadly and often deeply umbilicated; whorls angular or rounded, usually closely coiled, but often barely in contact; aperture sharply pentagonal to sub-circular; labrum generally sharp. The surface of the volutions is for the most part smooth, or showing only numerous lines of growth; but sometimes with one or more distinct longitudinal carinæ.

Passing now to the species represented in the locality already mentioned it is found that they are six in number; four of which are from the Kinderhook beds, and one from each of the two divisions of the Burlington limestone. Perhaps the most typical form of the series is *S. macromphalus* Winchell, [figs. 4a, 4b, 4c], a shell of medium size, with about four regularly rounded volutions and the spire more elevated than in any of the other five. It is of considerable interest to note the close relationship of this species and certain congeneric forms from the Devonian rocks, particularly *S. cyclostomus* (Hall) described from Iowa City, sixty miles to the northward from the city of Burlington and just beyond the limits of the Iowa Sub-Carboniferous area. This type finds its extreme development in *Straparollus* (*Euomphalus*) *springvalensis* (White), from the Kinderhook beds of Humboldt county, Iowa, in which the spire is very much elevated, the umbilical cavity exceedingly deep and the volutions numerous.

Associated with *S. macromphalus* is *S. barrisi* Winchell [figs. 5a, 5b, 5c]. It is nearly of the same size as the preceding, but has the spire somewhat more depressed, the umbilicus smaller, and the upper portion of the body whorl slightly flattened giving rise to an obtuse but noticeable angularity near the sutural line. A much smaller species also found at this locality is *S. ammon* (White and Whitfield), which is very similar to the Spergen Hill, Indiana, form—*S.* (*Euomphalus*) *spergenensis* (Hall).

In the oölitic band of the Kinderhook the large *S. obtusus* (Hall) [figs. 2a, 2b, 2c] occurs, but is not common. The shell is composed of about six volutions, the upper surfaces of which are in the same plane, as shown in fig. 2c. The umbilicus is consequently exceedingly broad and shallow. The whorls are regularly rounded especially in the younger examples, but the larger individuals often show a decided tendency to become subangular. In most of the specimens the turns are barely in contact and in many cases even separated towards the aperture so that there is, especially in internal casts, a striking resemblance to those evolute planorbicular forms for which Sowerby proposed the term *Phanerotinus.*

The two remaining forms to be mentioned are both from the beds of the Burlington limestone—the one occurring only in the lower part, and the other only in the upper. The first is *S. latus* (Hall) [figs. 1a, 1b] and is by far the largest species known from the locality, frequently having a diametric measurement of more than eight centimeters. The whorls above are nearly on a level and are sharply angular towards the sutural line and also just above the periphery, making the upper surface transversely flat or slightly concave. The carinæ are manifestly thickenings in the shell as exhibited in a cross section [fig. 1b] and as also shown by the regularly rounded natural casts of the interior of the shell. The volutions may also have an obtuse angularity below.

In *S. roberti* (White) [figs. 3a, 3b] the apical parts are depressed below the upper surface of the outer whorl, thus giving additional prominence to the carinæ; while the umbilicus is correspondingly more shallow.

It has been suggested that the latter form was the genetic successor of *S. latus*, and this is probably the case since the stratigraphy of the locality indicates that the various layers were laid down under practically the same physical conditions; and the testimony furnished by the exceedingly rich and varied fauna of the area amply corroborates the same conclusion. This would rather point to the assumption that the faunæ of the so-called Upper and Lower divisions of the Burlington limestone, and perhaps also even of the Keokuk in the immediate neighborhood, were closely related biologically and that they were not merely occupants migrating to the district at different times from divers localities which belonged to faunal regions having no actual relations.

EXPLANATION OF PLATE.

Fig. 1. *Straparollus latus* (Hall). *1a.* View of an average specimen

(from above). *1b.* Transverse section of same. Lower Burlington limestone.

Fig. 2. *Straparollus obtusus* (Hall). *2a.* A large specimen. *2b.* Transverse section of same. Kinderhook oölite.

Fig. 3. *Straparollus roberti* (White). *3a.* An example of medium size. *3b.* Transverse section of same. Upper Burlington limestone.

Fig. 4. *Straparollus macromphalus* Winchell. *4a.* A large specimen. *4b.* Apertural aspect of same. *4c.* Umbilical view of another example. Kinderhook beds.

Fig. 5. *Straparollus barrisi* (?) Winchell. *5a.* View from above. *5b.* Same from below. *5c.* Aperture of same. Kinderhook beds.

THE USE OF THE TERMS LAURENTIAN AND NEWARK IN GEOLOGICAL TREATISES.

By C. H. Hitchcock, Hanover, N. H.

In the January number of the American Geologist Mr. Joseph F. James endeavors to persuade geologists to use the term Laurentian for the marine Quaternary terrane for which the name Champlain is commonly employed. His reason is that the word *Laurentian* (in distinction from *Lawrencian*) was applied to this terrane by E. Desor "about the beginning of the year 1851," and before the same name had been suggested for the great fundamental crystalline system of rocks by W. E. Logan. This is in obedience to the right which a man has to claim the adhesion of others to his own original suggestions. This reason is a good one, but circumstances may render the canon nugatory, as is exemplified in the name of our continent. By right of discovery it should be called *Columbia;* yet everyone says *America.*

It is to be regretted that Mr. James did not examine my reference to the publication where Mr. Desor proposed the use of the name Lawrentian.[1] I quote the essential parts of the communication. "Mr. Desor called the attention of the society to the deposits of marine shells in Maine, on lake Champlain, and the St. Lawrence, and to the question of their probable origin." After correctly describing certain localities near lake Champlain and the St. Lawrence river it is added, "Mr. Desor had thus been led to the opinion that the sea had once filled the St. Lawrence, lake Ontario, and lake Champlain. As the deposits in these localities do not in the opinion of the geological party to which he was attached, belong to the true drift, they had proposed for them the name of the Lawrentian deposits, and he hoped the term would be accepted by geologists generally.[2]

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[1] Proc. Boston Soc. Nat. Hist., vol. III, p. 357, 1850.

Prof. H. D. Rogers was present and commented upon these clays and sands as he had seen them on the St. Lawrence and in New England and said, "The name offered by Mr. Desor he was very ready to receive as applicable to a local deposit;" and he says in the "Geology of Pennsylvania," 1858, vol. II, p. 775, "This marine Pleistocene formation has been appropriately named by professor E. Desor the Lawrentian clay."

In the communication of Desor to the Geological Society of France, quoted by Mr. James, p. 31 of the Geologist, he says, "As the deposits of this kind are most developed in the valleys of the littoral Atlantic, and particularly in the valley of the St. Lawrence and of its affluents, I have proposed to designate it under the name of *Laurentian terrane* to distinguish it from deposits containing fresh water fossils." W. E. Logan in his Report of Progress of the Canadian survey for 1850-51, under date of Aug. 20, 1851 (p. 8), speaks of this same marine deposit to which "Mr. Desor * * * * is disposed to give the name of Lawrencian."

These quotations indicate that Mr. Desor intended to name this terrane after the valley of the St. Lawrence river. The question arises, what is the adjective derived from it? The English form is *Lawrencian*, while the French is *Laurentian*. There should therefore be no controversy as to which of these modes of spelling is the correct one. H. D. Rogers, W. E. Logan, Z. Thompson, J. W. Dawson, and others, as well as Desor himself in his original proposal, use the English form. It is therefore improper to chide the reporter of the sub-committee upon the Quaternary for quoting Desor as the author of the term *Lawrencian.*

It does not concern us now whether it was judicious for Logan to suggest the name of the same sound for the fundamental gneiss; but it is clear that he took pains to derive the term from the Laurentide mountains. He says, (Report of Progress, Canada, for the year 1852-3, page 8), "it has been considered expedient to apply to them for the future, the more distinctive appellation of the Laurentian series, a name founded on that given by Mr. Garneau to the chain of hills which they compose." From his standpoint Laurentian was the proper term for the great system, and any use of a homophonous word for an insignificant terrane should not stand in its way. The geological public have thoroughly endorsed him. Prof. Dana used Laurentian for the Quaternary terrane in his presidential address before the A.A.A.S., in 1855, but later in his *Manual of Geology* and elsewhere uses the same word for the crystallines and Champlain for the clays.

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[2] It will be noticed that Desor's spelling is neither Laurentian nor Lawrencian, but *Lawrentian*, and Rogers spells it the same way. But Logan, Thompson and Dawson, his contemporaries, living on the terrane, understood the word correctly. The letter *w* decides the original intent to have been to use the English word, since this letter is not used in the French language; while the *t* and *c* are commonly interchangeable.

Is it not an axiom in geological nomenclature that if the proposer of a new term makes a mistake in orthography or etymology, it shall not debar the originator's claim to priority? In Agassiz's *Nomenclator Zoologicus* one recalls scores of instances in which an error of derivation is rectified, and the genus spelled differently from its first proposal, but it is still credited to its author. Now it was evidently intended to name this terrane after the St. Lawrence valley. Should it not, therefore, be more correctly written the St. Lawrencian terrane? The river is not the Lawrence river, whether written in French or English, and therefore the St. should be prefixed. It need hardly be added that with such correct rendering there would never be any conflict with the term Laurentian as applied to the crystalline system.

Should it ever be found desirable to discard the name Laurentian, as applied to the older rocks because of its preoccupation by another word, I would respectfully invite the attention of bibliographers to a term that precedes all others, viz., to *Atlantic*, as proposed by Featherstonhaugh in 1835. This gentleman in a report to the government upon the "Elevated country between Missouri and Red rivers," urged the necessity of giving a general name to the chain of mountains, as well as to the formations composing them, occupying the region of the primitive rocks of Maclure. It is the Blue Ridge, Alleghany mountains, etc. He says,[3] "It will be apparent, I think, to every geologist, that as this primary chain is the true boundary of the sedimentary rocks lying west of it, and forms so important a feature in the mineral structure of the country, it should receive a clear geological designation; and as it looks upon the Atlantic coast in its whole course, I shall propose the name of the ATLANTIC PRIMARY CHAIN." Further sentences make it clear that he excludes the Cambrian of Sedgwick from this appellation. I have gone into this subject in detail in my report upon the geology of New Hampshire.[4] While W. B. Rogers objected to this proposition in 1836, H. D. Rogers accepted it in a measure[5] in 1858.

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[3] Featherstonhaugh's Report, 1835, p. 83, Second edition.

It may be noted that Mr. Desor disclaims the origination of the application of the term Lawrencian, referring it to "the geological party to which he was attached." "*They* had proposed," etc., this name of Lawrentian. The reference was undoubtedly to Foster and Whitney, the government geologists of the lake Superior district, in whose employ Desor was at that time. I can not find the term used in any of the reports upon lake Superior, though it is claimed as original by Prof. J. D. Whitney in connection with Mr. Desor.[6]

It appears that the views of Mr. James condemnatory of those geologists who neglect to say Laurentian for a part of the Quaternary are not shared by his colleagues upon the U. S. Geological Survey, since Mr. W. J. McGee has taken the pains to devise a new expression—the "Columbian formation"—to represent its equivalent in our nomenclature. This can not be from lack of familiarity with Desor's paper, since he has referred to that one which has correlated the Laurentian of the north with the Pleistocene of the south. The term Champlain has been in use for many years to embrace both the littoral and marine deposits now referred to the Columbia.

The attempt to revive the local name of [7]Newark, N. J., for the Triassic system of the Atlantic coast, seems to be unadvisable for many reasons. *First.* An essential feature of a name derived from a geographical locality is that the terrane should be exhibited there in its entirety or maximum development. The territory of Newark does not contain one-fourth part of the thickness of this sandstone, and that which is visible is only a fraction of this fourth. Had Mr. Redfield used the name of ***Passaic***, in allusion to the river of that name, which flows over the entire system, it would have been truthful and comparatively unobjectionable. ***Second.*** The name of Connecticut or Connecticut River sandstone has precedence over Newark. My father is acknowledged to be the first of geologists to have understood this terrane, and he identified it with the Trias or New Red sandstone of Europe. This was before the days of putting geographical names upon groups of strata in this country; but he and others constantly used the expression of Connecticut sandstone or its equivalent. The following gentlemen have made use of this expression in their writings before the time of Redfield's proposal in 1856, though none of them have formally proposed it as a geological term: E. Hitchcock, Sir Charles Lyell, Dr. James Deane, Dr. S. L. Dana, Dr. Joseph Barrett, Dr. C. T. Jackson, Dr. John C. Warren, T. T. Bouvé, and Prof. Jeffries Wyman. ***Third.*** In his lectures before the class of 1857 in Yale college Prof. J. D. Dana adopted the name of Newark for these sandstones, and presumably on other occasions. In his Manual of Geology published in 1861, and the later editions, he makes no allusion whatever to the name of Newark. These facts show that this gentleman, whose authority is second to none, saw fatal objections to the use of Redfield's name. Prof. O. C. Marsh in presenting a table in Dana's Manual to show the succession of vertebrate life, formally uses the name of Connecticut River sandstone. This usage is not cited in support of a claim for priority. ***Fourth.*** While the New Jersey terrane possesses the distinguishing features of the Trias, quite as well as the one in New England, it is fitting that the local geographical name should be derived from the latter, since that was the field of discovery of the fossil footmarks which has given the Connecticut valley an honored reputation throughout the scientific world. Mr. Russell has presented a long list of authorities who have written upon the Trias, and it is observable that only one of them has used the name of Newark—and that was the writer who proposed the use of the name. It seems hardly for the good of science to attempt to resuscitate a term that everyone has avoided using. ***Fifth.*** In the language proposing the new name for the terrane, the author finds it necessary to explain that these New Jersey sandstones are thoroughly identified with those of the Connecticut valley by foot[illegible]nts and other fossils. The Connecticut sandstones are [illegible]ce the original pattern by which we are to judge of the [illegible]ensions and qualities of all the other terranes. What can [illegible] more fitting than to make this original pattern the standard of comparison for all the other Triassic areas? It seems inappropriate, however, to attempt to use either local designation for any of these rocks west of the Mississippi.

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[4] Geology of New Hampshire, vol. I, p. 525.
[5] Geology of Pennsylvania, vol. II, p. 747.
[6] Amer. Jour. Sci., II, vol. 23, p. 314.

THE GLACIAL GEOLOGY OF THE IRONDEQUOIT REGION

By Charles R. Dryer, Fort Wayne, Ind.

At the very head of the great bight on the south shore of lake Ontario opens the mouth of a narrow gorge which extends some ten miles into the land. The lower half of it is occupied by the waters of Irondequoit bay, the mouth of which is one mile wide and now nearly closed by a sand bar. The bay rapidly narrows to less than half a mile, but in its upper half abruptly widens to three-quarters of a mile. Above the head of the bay the gorge is prolonged southward to the village of Penfield, but there is no evidence that the bay ever occupied the whole of it. The walls rise on either side to a hight of 170 feet and are everywhere of drift worn into characteristic forms of knob and peak. The lateral ravines in the upper half of the bay reveal the presence of Clinton and Niagara shales and limestones a few hundred feet back from the shore and rising nearly to the level of the country on either side. The real phenomenon to be considered, then, is a rock gorge partially filled and marked by drift. Its limits can be approximately outlined and prove to enclose a space one mile wide at the top; the depth of the drift at the bottom is unknown, but the bay is in some places 70 feet deep, so that the total depth of the gorge can not be less than 250 feet. It is boat-shaped and resembles the basins of the "finger lakes." It is blocked at the south end by a precipitous wall of drift, so that its actual length can be determined only by boring. The Irondequoit river enters at the southeast corner by a series of rapids.

Twenty miles south of the head of the bay the Irondequoit basin is enclosed by a glacial moraine of strong features and

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[7] American Geologist, March, 1889, p. 178.

large proportions. It forms an irregular V, broken by valleys into three sections. The eastern section extends from a point south of Fairport to the village of Victor. It is a range of drift hills two or three miles wide, seven miles long, and rising near its center, at the Turk's hill station of the U. S. Lake Survey, to 681 feet above lake Ontario. The southern section is separated from the eastern by a narrow valley and extends from Victor southwestward seven miles to the village of West Bloomfield, where it is banked up against a ridge of Hamilton shale. This section rises near its middle to a hight, in Hopper hill, not inferior to Turk's hill. The western section is an isolated group of extremely irregular hills in the townships of Mendon and Pittsford. It is separated from the other sections by a level interval of three to four miles and is prolonged northeastward by a series of parallel drumlin-like ridges nearly to the village of Pittsford, a point directly opposite the north end of the east arm of the V. The basin of the Irondequoit river is enclosed by these moraines except in two places. The narrow valley between the eastern and southern sections opens into the valley of Mud creek, which is the head of the Oswego river. The wider interval between the southern and western sections is continuous with the valley of Honeoye creek.

The opening between the ends of the V, two and one-half miles in width, is almost closed by a kame which extends from Cartersville on the west to and beyond Bushnell's basin on the east. The north end is a sharp ridge of very coarse gravel, fifty feet in hight, one mile long, and in shape like a rude fish-hook. It is separated from the southern portion by the channel of Irondequoit river, which has cut the kame completely in two. In the southern portion the gravel is overlaid by fifty feet of fine sand which spreads out toward the southeast in a sheet a mile or more in width. This kame forms a dam across the valley, complete except for an interval of less than one-fourth of a mile on its western side. The Erie canal avails itself of this kame to cross the valley and by a fifty-foot embankment restores what probably once existed as a natural feature. South of the kame the valley is as level as a floor for three miles up the stream and was evidently once the site of a lake whose waters were held back by the kame as a dam. Within half a mile north of the Cartersville kame a diffused deposit of sand begins and soon assumes the shape of a massive and well defined ridge which extends northward two miles and ends abruptly at the bank of Allen's creek.

Perhaps the most remarkable feature of the region is the so-called "sugar loaves." They are isolated, conical, sand hills, rising from the bottom of the Irondequoit gorge to a hight level with the top of its walls or nearly so. Two small ones stand near the head and a group of four large ones three miles below. The latter are islands surrounded by channels of the stream. The most symmetrical one is an almost perfect cone 20 rods in diameter and 150 feet high. Such sharpness of outline and high angle of slope in a pile of sand is rendered somewhat less marvellous by the fact that the cones are covered by a growth of pine trees and deciduous shrubs. How these forms originated is an interesting and difficult question, but certain features of the surrounding region seem to throw light upon it. The sugar loaves evidently form a part of the Irondequoit kame system, the larger group being a continuation in a direct line of the above described kames. That all are remnants of one originally continuous kame is an assumption warranted by their structure and position. Again, two of the cones are almost connected with the east wall of the gorge by curved ridges of the same material, now no more than half as high and cut off from the cones by channels of the river. In short they are unusual if not unique forms resulting from the general laws of drift erosion, here acting under peculiar conditions. In the washing out of the drift from the gorge parallel tributaries left high narrow ridges between them, while at the same time shifting channels of the main stream, at first flowing at a much higher level than now, cut a cone off from the end of each ridge. They are analogous to the buttes, monuments and other erosion forms of the Rocky Mountain plateau. The whole region is extremely suggestive of questions as to the origin of the peculiar forms of knobby drift, and the laws, processes and limitations of drift erosion, problems which do not seem as yet to have been adequately considered. The Irondequoit cones seem to the writer to stand as dumb but eloquent protests against any theory which would assign a

length of 80,000 years to the period during which they have been subjected to erosion.

Between the Irondequoit gorge and the Genesee river south of Rochester lies a remarkable range known as the Pinnacle hills. They extend from the river a little north of east five miles in a line directly toward the group of larger cones. The range is simple, straight, symmetrical, regular except for some serration, devoid of spurs and completely isolated on all sides by a level plain. Its highest point rises at the U. S. Lake Survey station 502 feet above lake Ontario and about 200 feet above its base. The lower half is composed of coarse gravel and the upper half of sand. Its position indicates that it belongs to the Irondequoit system, and its structure shows that it is a gigantic kame, differing only in size and direction from those before described, the axis of which it would intersect near the sugar loaves.

The Irondequoit gorge undoubtedly had its origin in the channel of some preglacial river. Present appearances point to the Genesee as its original occupant, since from the Pinnacle hills to its mouth the present channel of that river is postglacial; but the length of the gorge and the path by which the river reached it are both equally buried in mystery. The possibility that it may have given passage to a river which flowed southward into the Susquehanna is not unworthy of consideration. This conjecture receives some support from the fact that the line of maximum depth in lake Ontario approaches the south shore with a sharp angle at a point just opposite the mouth of the bay.[1] At some time in the latter part of the glacial period a more or less independent lobe of the ice sheet, intermediate between the glacier of the Genesee and that of the "finger lakes," pressed through the gorge, which it widened and deepened, and maintained itself long enough to form, with the help of its neighbors, the moraine twenty miles to the south. When the glacier retreated it left the valley and gorge blocked with drift which has since been removed to the extent described. The washing out has been accomplished chiefly by the Irondequoit river when its volume was much greater than at present.

There is, perhaps, no equal area in the world where all the

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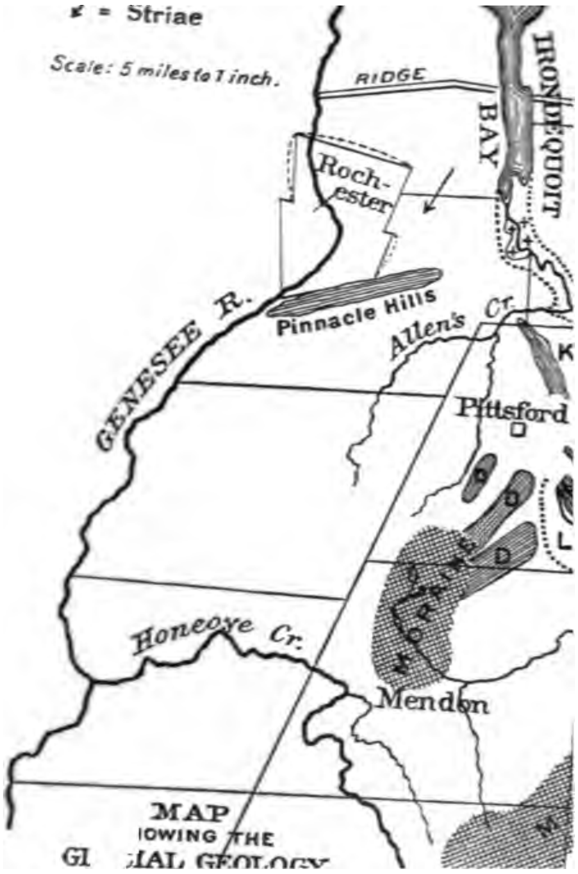
[1] See map opposite p. 279, Wright's "Ice Age in North America."



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Scale: 5 miles to 1 inch.
RIDGE
IRONDEQUOIT
BAY
Roch-ester
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GENESEE R.
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MAP
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peculiar features of drift topography are so fully exhibited. Winding ridges, massive domes buttressed and scored with ravines, flat-topped buttes with precipitous walls and reentering angles, conical hills, dimpled plateaus, deep glens and secluded valleys, "soap-dishes" and kettle-holes of perfect symmetry,—all in the greatest profusion and variety, form a landscape of strange and peculiar beauty. The Mendon hills constitute a morainic island from the peaks of which all these features may be seen at a single glance. They include a cluster of five small but typical morainic lakes. "The ridge," a former shore line of lake Ontario, intersects the Irondequoit gorge two miles above its mouth and ends abruptly on the brink, the gap between the cut ends being one mile wide. Either the entire excavation of the present drift gorge has been accomplished since this shore line was formed, or the loop which it may have made around the head of the bay has been obliterated.

NOTE ON A SPECIMEN OF *CONULARIA MISSOURIENSIS* SWALLOW, WITH CRENULATED COSTÆ.

By S. Calvin, Iowa City.

A very interesting specimen of Conularia from the horizon of the St. Louis limestone in Brown county, Illinois, has lately come into my possession. This specimen agrees in nearly all essential particulars with the form doubtfully referred by Meek and Worthen (Geol. survey of Ill., Vol v, p. 541. Plate 22 Fig. 5,) to *Conularia missouriensis* Swallow. I have not seen Swallow's type specimen, and in the absence of figures it is impossible to compare the specimen before me with Swallow's species. There is little doubt, however, that this is the form described by Meek and Worthen, *loc cit.*, and yet in the description of these authors special emphasis is placed on the "apparently smooth, sharp, transverse costæ," and on the apparent absence of crenulations on the costæ and spaces between. Fortunately in this new specimen a part of the surface is in an excellent state of preservation, and shows that in this remarkably large and, in the main, plainly ornamented species of Conularia, the sharp edges of the transverse costæ were very distinctly crenulated, the crenulations taking the form of a row of minute, blunt, rounded prominences along the summit of each sharp, carniated rib. It is assumed that the smooth edges of the costæ in the specimen described by Meek and Worthen were due to weathering. The same smooth condition of the costæ obtains over part of the surface in the specimen before me. Moreover it is hardly conceivable that two species should occur at the same horizon differing from each other in nothing but the presence or absence of costæ crenulations. If, however, it should be proved on farther investigation that the surface of the specimen used by Meek and Worthen was intact, then the differences in the two forms may be recognized by calling the one represented by the subject of this note *Conularia missouriensis*, var, *hersmani.*

THE SESSION OF THE INTERNATIONAL GEOLOGICAL CONGRESS IN PHILADELPHIA.

By PERSIFOR FRAZER, Philadelphia.

It is well known to the readers of the GEOLOGIST how the congress at its last session in London decided to postpone its meeting in Vienna until after the session in the United States. At the time this decision was taken nothing had been said about a quadricentennial world's fair to be held in this country, so that when this question arose it became necessary to consult the bureau or governing body of the Congress in order to ascertain whether or not it was the desire of the foreign members to postpone the session which ought to be held in 1891 until 1892, and in order to give the visiting European geologists an opportunity to see this fair and to attend the Congress at the cost of one journey across the Atlantic.

The following responses were received from influential members of the Bureau constituting in the aggregate more than a majority of that body.

These answers are condensed from letters covering in some cases four and five pages each.

Prof. Joseph Prestwich, president of the Congress, has taken steps to ascertain the opinion of the officers of the Congress and will communicate more definitely later.

Dr. J. W. Hulke and *Mr. W. Topley*. Have consulted most of the English members and find the general opinion to be against any such postponement for two reasons: (1) It is undesirable to make any alteration in the date of the meeting unless absolutely necessary (as in the case at Berlin). (2) The business of the Congress might suffer from the distractions incident to a world's fair. If the American committee, however, desires the postponement these gentlemen will take the necessary steps to secure the formal sanction of the Congress. The American committee should obtain the opinions of Beyrich, Capellini, Dewalque, Hauchecorne, and Renevier.

Prof. T. McKenny Hughes. Personally I have no objections to the postponement to '92 if it recommends itself to your committee, but before answering categorically I wish time to consult other members of the last session.

G. Dewalque. While the exposition will bring more geologists to the Congress its distractions will turn their attention from its work. Besides a decision of the Congress should not be changed without grave reason. But the committee on organization is best able to decide this question and we shall abide by its decision.

E. Beyrich. The postponement of the Congress will be desirable if it secure a session during the continuance of the world's fair.

G. Capellini. The idea of making the date of the Congress and Exposition coincide has been found excellent by all my colleagues whom I have been able to consult. I was asked in France by many geologists to urge this postponement. It appears that the Englishmen are not of this opinion but it is to be hoped that after the vote of the majority they will agree to the postponement to 1892. You may regard my vote for it as that of all the Italian geologists interested in the Congress.

E. Renevier. I have absolutely no objection to the postponement of the Congress to 1892.

C. LeNeve Foster. It will be well to adjourn the session from 1891 to 1892 in view of the probability of the international exhibition in America during the latter year.

C. Barrois. Personally I prefer '92 to '91, but the Americans should decide.

K. Martin. The postponement of the Congress on the ground proposed seems desirable.

J. F. N. Delgado. I adopt on the question of the postponement entirely the views of the signers of the letter of inquiry.

A. de Lapparent. My personal opinion is that there is every advantage in causing the date of meeting of the Congress to coincide with that of the proposed exposition by the United States.

Dr. Zittel. I would leave the decision entirely to the American organization committee and will agree with any conclusion to which it may come whether to hold the meeting in 1891 or 1892.

J. Vilanova. I give my complete assent to the happy thought of convening the Congress in 1892 and promise my attendance.

A. Inostranseff. I find the idea very felicitous of adjourning the Congress to 1892, and send you my consent.

M. Neumayr. Before answering your circular I addressed a note to some of the most authoritative of our geologists. The unanimous opinion (which I share) is that there is no objection to such postponement if our American colleagues think it useful to the objects of the Congress.

J. Szabó. I think the proposition sufficiently called for, and I have the honor of declaring my support of it.

F. Giordano. It is my opinion and that of several of my colleagues from here that it is advisable to postpone the Congress from 1891 to 1892 which is to meet at Philadelphia.

T. H. Huxley. My answer to your letter of the 22nd of November has been unfortunately delayed in consequence of my absence from home. As you may be aware ill health prevented me from being present at the meeting of the Congress in London or from taking any part in its subsequent proceedings. In reply to your inquiries, therefore, I can only say that I shall acquiesce in the demands of the majority of my colleagues.

T. Sterry Hunt. I think it well to postpone the Congress to 1892.

Persifor Frazer. If the world's fair is to be held in 1892, it would seem unquestionably better to postpone the next session of the Congress till then, but if (as seems not improbable) the world's fair itself is to be adjourned until 1893, the date fixed by the Congress itself should stand. I am in favor of leaving the decision to the committee on organization.

G. H. Williams. I am in favor of postponing the meeting till 1892 if the international exhibition is held in that year. I do not, however, think that the meeting should be put off later than 1892.

It will be seen that a strong preponderance of opinion is in favor of postponing the session for one year. Few of the voters have expressed any opinion as to the postponement for two years, because probably this possible contingency did not suggest itself, but all those who have taken it into account are opposed to a two years' postponement. In view of these facts it is well to consider that the strong probability is that the meeting will take place as first designed, in September, 1891.

The time seems very short to prepare for this eventuality. When the Congress at Berlin was over, the British committee acting through Mr. Topley immediately took steps to inform scientific bodies throughout the world of the place and date of the next one, and to invite them to become subscribers to this Congress, holding out the inducement that in this manner the full proceedings and published documents would be sent to such subscribers at the nominal price of their subscription (10 shillings). Over a score of such notices in different forms were printed in the scientific journals of America and in this way there was a larger subscribing membership from the United States than from any other part of the world (except perhaps England). It was intended that these subscriptions should raise an important part of the expenses and lighten the burden of those who contributed money outright for defraying the necessary expenses of the Congress.

The London session was not as expensive as the Philadelphia session will be for many reasons, one of the strongest of which is, that in America we have made it our habit to do things of this kind on a scale of liberality which may in part atone for our newness as a nation. What Chicago is to the eastern cities of this country, that is the United States to the countries of the old world. Rightly or not we have made foreigners expect this of us and we must keep our reputation up or forfeit it. Now the expenses of the London session were chiefly of four kinds, viz:

The expenses of installation in the University of London, printing circulars, printing the volume of proceedings, etc, etc., were estimated to reach about 5,000 dollars, but it has been found that they fell but little short of 6,000 dollars.

But the expenses have exceeded the estimates and the committee finds itself lacking £150 to £200, say about $1,000.

Nothing is allowed here for the rent of rooms or the expenses of excursions. The University of London furnished the halls for the collections and for meeting, luncheon, etc., without charge, and those participating in the excursions paid each for himself, though doubtless at a reduced rate.

Without these expenses, which must necessarily be included in the expenses of a local committee in this country, the expenses of the London committee for the four items enumerated amounted, roughly speaking, to about $6,000.

If any attempt is made at entertainment and excursions à l'americaine here our expenses can not well be less than double that amount and the committee which must raise it could hardly begin too soon.

But there are other facilities which London enjoyed that are not to be found to anything like the same extent in this country. Among these are printing and proof reading of scientific matters in French, German and other languages; constant and inexpensive transportation to and from the meetings. These things must be provided by special arrangements which must necessarily be paid for by the local committee. Mr. Topley gave his earnest and practically his undivided attention to the last Congress for many months beforehand and during its session, and has been busy with its volume, etc., ever since. During the session Dr. C. LeNeve Foster, an admirable French scholar, Dr. Charles Barrois, and Mr. l'abbé Rénard spent every night far into the morning hours in order to correct the proof of the Procès Verbal of the Council and that of the Congress of that day, which were laid on the desks of the members of those bodies on their assembling at 9 and at 10 o'clock respectively next morning. Without such efficient help as that of those gentlemen, and especially of Dr. Barrois who résumèd with rare tact and judgment the remarks of those who could not speak French before the Congress, it is difficult to perceive how the work could have been carried on.

THE GEOLOGICAL HISTORY OF THE QUEBEC GROUP.

By T. Sterry Hunt, LL.D.

The history of the Quebec group fills a considerable place in American geology, and I have been at some pains to write and to publish elsewhere the principal facts regarding it. As the questions involved therein are still imperfectly understood it has seemed proper to me as the only survivor of those who were present at the naming of this group, and as the one who wrought its downfall, to rehearse briefly its history.

In the American Journal of Science for February, 1890, is a review by Mr. Charles D. Walcott of a second report by Dr. R. W. Ells, of the Canada geological survey, on the geology of parts of the province of Quebec, wherein he treats of the uncrystalline fossiliferous strata named by Logan the Quebec group, and also of the crystalline schists adjacent to them in the hills on the east and south, described by Logan as being of contemporary age, and the result of a so-called metamorphosis over a large area of the lower portions of the same Quebec group, and hence mapped and designated by him as the Altered Quebec group. The reviewer refers to this region of eastern Canada as "the battle ground where Logan and his adherents have been finally driven from position to position until there is now little left to defend of what seemed in 1863, a well-supported position." Ells moreover, after his studies of the fossiliferous rocks of the group, concludes, according to Walcott, that the farther use of the name of Quebec group for the uncrystalline strata in question "appears not only undesirable but to a certain extent objectionable," although the terms Levis and Sillery may be retained for the subdivisions.

We are next invited by the reviewer "to consider the breaking down of this elaborately constructed geological group, built up by the labors of Sir W. E. Logan and his associates, Mr. E. Billings, Dr. T. Sterry Hunt and Mr. James Richardson." Selwyn, we are told, "began the work of disintegration when he showed in his report for 1877-78 that the rocks of the Canadian extension of the Green Mountain (or Sutton Mountain) range and its northeasterly extension were arranged in an anticlinal instead of a synclinal form as supposed by Logan. This removed the keystone on which the stratigraphic structure of the altered portion of the Quebec group was based." The crystalline schists were now referred to a "pre-Cambrian group, probably Huronian;" and what Selwyn had previously called a Volcanic group (unrecognized however by Logan and his assistants) was imagined to be pre-Cambrian.

Besides the false conception with regard to the stratigraphical structure, according to Ells, "another source of error, and probably the most considerable, was the assumption that the metamorphic rocks of that area must of necessity be the equivalent of the unaltered sediments of the St. Lawrence region, a theory which once suggested seems to have been unhesitatingly maintained, although for its support unnecessary inversions of strata and profound chemical changes were requisite." Still farther Ells has shown, according to Walcott, with regard to the uncrystalline Quebec group, that "the order of succession was inverted by Logan, and that the Levis series is conformably superjacent to the Upper Sillery (Lauzon of Logan) while the Lower Sillery forms the base of the section in the vicinity of Quebec."

There are thus embodied in the preceding paragraphs four important propositions:

1. The crystalline schists of the Green Mountain range and of its prolongation northeastwards in the province of Quebec—the so-called Altered Quebec group—do not form a synclinal, and are not metamorphosed paleozoic rocks, but on the contrary constitute an anticlinal axis of ancient strata, "pre-Cambrian and probably Huronian" in age.

2. The uncrystalline fossiliferous strata along the western and northern flanks of this range are newer rocks of Cambrian and Ordovician age.

3. The order of these newer strata was mistaken by Logan, who placed the Sillery at the summit and the Levis at the base, whereas the true succession shows the Sillery at the base, followed conformably by the Lauzon, the Levis being at the summit.

4. The name of the Quebec group should be rejected in geology.

To all of these propositions I assent most heartily, the more so that I have maintained them nearly twenty years, for the most part single-handed, and on every favorable occasion.

A slight acquaintance with the history of geological opinion as to the crystalline rocks of the Green Mountain range and their relations to the adjacent uncrystalline sediments would have shown our authors that the views advanced concerning these two classes of rocks were not simply those of "Logan and his adherents," but of the majority of American geologists for the past fifty years. Amos Eaton and Ebenezer Emmons had, it is true, taught that the region of crystalline rocks in question constitutes an ancient anticlinal axis, and that the uncrystalline sediments along its northern and western base were deposited unconformably upon these old rocks and were in part made up of their ruins. The doctrine of regional metamorphism, then and since carried to great lengths both in Europe and in America, was, however, adopted by Mather; whose large quarto volume on the geology of the Southeastern District of New York, published in 1843, was at once generally accepted as authority, so far as New York and western New England were concerned. The continued eastward dips observed in the paleozoic strata east of the Hudson and the supposed gradual transition of the uncrystalline sediments into crystalline schists led Mather to assert that these latter were nothing else than the upper portion of the Champlain division of the New York paleozoic series, or the so-called Hudson slates in an altered condition. This view was cited with approbation in 1844 by H. D. Rogers, who, in company with his brother, W. B. Rogers, attempted to show in 1846 that the gneisses and mica-schists of the White Mountain belt, lying to the east of the Green mountains, were still newer rocks, and represented probably the horizon of the Oneida, Medina and Clinton of the New York series. Chas. T. Jackson moreover in his volume on the geology of New Hampshire, in 1846, while he declared that the White mountains constitute an axis of the primary rocks, regarded the crystalline schists of the Green mountains as altered paleozoic strata, the metamorphosis of which he declared to have been effected by intrusive serpentines and intrusive quartzites.

As regards the geological horizon of the paleozoic sediments in question, we may note that Amos Eaton maintained the existence in the region in debate of two distinct series each consisting principally of argillites and sandstones, which he called the First and Second Graywackes, much resembling each other; the first of these being below the horizon of the Trenton limestone, and the second above it, or between this same and the Niagara limestone. The absence of such a Graywacke series in parts of New York below the Trenton led Mather to deny its existence, and to confound in one group the First and Second Graywackes along the Hudson valley, under the common name of the Hudson slates (called collectively by Vanuxem, the Hudson-River group); which were assumed to be the equivalent of the Loraine shales, with the addition of the Utica shale below and the Gray or Oneida sandstone above. Mather's view of the post-Trenton age of the whole of the Hudson River Graywacke and of its extension north and east through Vermont to the city of Quebec, was accepted by James Hall, by C. B. Adams, by W. B. Rogers, and for a time by Emmons himself; who, in his final report in 1842 on the geology of the Northern District of New York, describes the rocks at Quebec as Loraine shales with their overlying sandstones, which he speaks of as extending from the valley of the Hudson through eastern Vermont to the city of Quebec. In another chapter of the same volume, however, Emmons reverts to the teaching of Eaton, and in his subsequent writings includes these rocks in the First Graywacke—his Upper Taconic series. This view, however, was not accepted by other geologists. James Hall continued to maintain Mather's doctrine of the post-Trenton age of the Graywacke series in question. C. B. Adams, charged with a geological survey of Vermont, held in 1846 that the Red Sandrock of that state, "now included by Emmons in the First Graywacke or Upper Taconic, is of "the period of the Medina sandstone and the Clinton groups," while W. B. Rogers, in 1851, considered that limestones, which near Burlington, Vermont, are associated with this Red Sandrock are probably "of the Medina group."

When, then, in 1847, Logan began the examination of the belts of crystalline and uncrystalline rocks from the frontier of Vermont to the vicinity of the city of Quebec, he framed no new hypothesis, but adopted without question, the views of Mather, Hall, Adams and Rogers as to the post-Trenton age of the uncrystalline sediments, In like manner he accepted unhesitatingly Mather's hypothesis of their stratigraphical equivalence with these of the crystalline schists of the Green Mountain range, sustained as it was by the approval of the Messrs. Rogers and of C. T. Jackson. Logan, constitutionally diffident, and venturing in a new field, was disposed to defer to those whom he, like myself, his young assistant in the campaigns of 1847-49, had been taught to regard as authorities not to be questioned. Hence it was that the limestones and argillites of Pointe Levis were described as Hudson-River group, supposed to be younger than the Trenton limestone of Beauport, while the great mass of 2000 feet of Sillery sandstone, apparently overlying these, was regarded as the equivalent of the Oneida or Shawangunk sandstone and conglomerate of New York; as may be seen in the little colored map in the *Equisse Géologique du Canada* published in Paris in 1855. The crystalline rocks adjacent to the south and east were in like manner designated as Altered Hudson-River group. The doctrine of regional metamorphism being then taken for granted, and at the time scarcely questioned, I sought for proof of it alike in the field and in the laboratory, and found in the composition of certain detrital beds near the crystalline schists, then regarded as beds of passage, evidence apparently confirming the metamorphic hypothesis.

In the views of his masters, then implicitly accepted, Logan made in his life-time only a single change, one forced upon him by the results of the paleontological studies of Billings, which showed that the so-called Hudson-River group at Pointe Levis was really, as Eaton and, in his later view, Emmons had maintained, not post-Trenton in age, but pre-Trenton, and belonged to the First Graywacke of Eaton. It is unnecessary to remind the reader that subsequent researches have shown the same to be true of the greater part of the sedimentary rocks in question from the valley of the St. Lawrence to that of the Hudson.

Logan's first acknowledgement of this conclusion was in a letter to Barrande, dated in 1860 but published March 1861, to the effect that certain fossiliferous strata included in the Hudson-River group at Quebec had long been maintained by Emmons to be older than the Trenton, adding "The fossils which have been obtained this year [1860] at Quebec pretty clearly demonstrate that he is right." Instead, however, of calling these Upper Taconic with Emmons, or First Graywakce with Eaton, Logan proposed in his letter to Barrande the name of Quebec group, of which the apparently overlying Sillery sandstones constituted the summit, the great underlying mass of shales and limestone being called the Levis, and an intermediate division being subsequently proposed with the name of Lauzon. With the exception of this change in horizon of the group rendered inevitable by the progress of paleontological study, and the corresponding change in name, no alteration was made in the views of Logan, which were still those of Mather. The Hudson-River group of the latter was found to be pre-Trenton and was named Quebec group, and the crystalline schists were henceforth called Altered Quebec group instead of Altered Hudson-River group.

But the way was slowly preparing for the overturning of the whole hypothesis of Mather, and the establishment of the older view of Eaton and Emmons with regard to those crystalline schists, as well as to the uncrystalline sediments. My studies of the crystalline rocks of the Ottawa and the great lakes had shown close resemblances between certain of these rocks and the crystalline schists of the Green Mountain range as seen alike in New England and in Quebec, and I was led to consider carefully the teaching of Eaton and of Emmons, that this range is itself a primitive or pre-Cambrian axis more ancient than the uncrystalline sediments along its western and northern base. I had found and described in 1857 in conglomerates interstratified with the fossiliferous beds of the Hudson-River group at Pointe Levis fragments of purplish and greenish lustrous schists, apparently chloritic, and had moreover described in 1861 the presence of pebbles of green and bluish slates in conglomerates of the Potsdam age near the outlet of lake Champlain: in both cases evidently derived from rocks of greater antiquity, apparently the primitive schists of Eaton.[1]

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[1] See History of Cambrian and Silurian in *Chemical and Geological Essays*, page 400.

In 1862 Thomas Macfarlane, who was familiar with the crystalline schists of Norway, which there underlie the Cambrian, compared them with those of the Green Mountain range and of the great lakes already noticed, and concluded that they are all essentially similar, lithologically. Bigsby, the earliest scientific observer of these rocks in the Northwest, moreover announced independently, in 1863, their apparent identity with the crystalline schists of Scandinavia. In the *Geology of Canada* 1863, I called attention (p. 705) to these resemblances, mentioning that the crystalline schists of the north shore of lake Superior "recall the strata of the [altered] Quebec group."

The whole question of their probable identity, and of the great antiquity of these crystalline schists of the Green Mountain range as evinced by the pebbles and fragments found at different localities in the uncrystalline lower paleozoic sediments was at that time repeatedly discussed with Logan, but, as I have elsewhere said, "official reasons then and for some years afterward prevented the writer from expressing any dissent from the views of the director of the geological survey of Canada." It was not until after having spent some months in 1869 and 1870, in geological studies along the southern coast of New Brunswick, and made examinations at various points on the coasts of Maine, Massachusetts and Rhode Island, that I ventured to declare in October 1870, in a communication to the Boston Society of Natural History, (Proceedings XIV, 45, 46,) entitled "Notes on the Geology of the vicinity of Boston," that the crystalline schists (previously described as altered Devonian), which near St. John, New Brunswick, underlie unconformably the Cambrian sediments, belong to the same series as those underlying such sediments near Boston; classing them moreover with similar crystalline rocks at Newport, Rhode Island, and on the coast of Maine. It was then said "to the same series I refer the great range of gneissic and dioritic rocks with serpentines, chloritic, talcose and epidotic schists which stretches through western New England," that is to say, the Green Mountain range. In a farther notice of this series of rocks in February, 1871, it was added, "they apparently belong * * * to the great Huronian system," (Amer. Journ. Science III., 1, 84). See also *Azoic Rocks*, being Report E., second geological survey of Pennsylvania, page 114. Having reached this point, the attention of Logan was once again invited, and

I proposed to serve as his guide to the more important localities, a proposition which he abruptly refused. Advancing years and failing health made him unfit to bear any questioning as to the correctness of the views which he had so long maintained as to the Green Mountain range, and the consequence as is known to many, was a severance of the intimate and friendly relations of half a life-time and my withdrawal in June, 1872, from the geological survey of Canada, after more than twenty-five years of service.

The above conclusions as to the Green Mountain rocks were reiterated and enforced at length in my address in August 1871, as retiring president of the American Association for the Advancement of Science, which the reader may consult in the published Transactions, and also in my volume of *Chemical and Geological Essays* under the title of "The Geology of the Appalachians." It is there said, "Although I have in common with most other American geologists maintained that the crystalline rocks of the Green mountains and the White Mountain series are altered paleozoic sediments, I find on a careful examination of the evidence, no satisfactory proof of such an origin, but an array of facts which appear to me incompatible with the hitherto received view, and lead me to conclude that the whole of our crystalline schists in eastern North America are not only pre-Silurian but pre-Cambrian in age."

These conclusions were arrived at and published while I was yet an officer of the geological survey of Canada. They were, moreover, explained at length on many occasions to Selwyn, already in 1870 director of the survey, who was furnished with my various publications on the question in 1870, 1871, 1872, 1876 and 1878, and soon began to investigate the arguments urged by me against the metamorphic hypothesis maintained by Mather and by Logan, as to the crystalline rocks of the Green Mountain range. The result was that in 1878 I was able to write "The investigations of the geological survey of Canada during the years 1876 and 1877, have, according to the director of the survey, demonstrated the correctness of the view so long maintained by the writer, that the crystalline rocks of the Green Mountain series belong to a more ancient system, which underlies unconformably the uncrystalline Cambrian sediments of the Quebec group."[2]

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[2] Azoic Rocks Rep. E., Second Geol. Survey of Penn., p. 198.

Moreover as appears from the official report of the First International Geological Congress, held at Paris in September 1878, after a communication by myself on the crystalline rocks of North America, Selwyn, who was present, made some remarks which were thus resumed. "As to the crystalline rocks, which form the Green Mountains in the province of Quebec, they are according to Sir. W. E. Logan, altered paleozoic strata, making part of the Quebec group. Mr. Selwyn however feels it his duty to say that the recent researches of the geological survey of Canada have confirmed the correctness of the view maintained for some years by Mr. Sterry Hunt. These crystalline rocks appear to belong to a more ancient terrane than the fossiliferous strata of the Quebec group and probably form the equivalent of the Huronian."[3]

C. H. Hitchcock who had for some years maintained a similar view, published in 1877 his final report onthe geology of New Hampshire wherein he calls the Altered Quebec group of Logan Huronian and in the second volume morever gives a map of New England and eastern Canada in which the areas of the Green Mountain series in Vermont and New Hampshire are described and represented as Huronian. To say as Mr. Walcott has done that "Selwyn in his report of 1877-78, [dated and published in 1879] began the work of disintegration" in the Quebec group, by showing the anticlinal structure and the unconformable infraposition of these crystalline rocks is so obviously contrary to all the facts of the case as to require no comment. Selwyn's recognition of these facts and his frank avowal before the International Geological Congress in 1878 was neither more nor less than a final surrender on the part of Logan's successor to the persistent attacks upon the famous hypothesis of Mather and Logan, begun by me in 1857 and 1861, and supported by Macfarlane on lithological grounds in 1862. The view finally formulated by me in 1870 and 1871 was but a return, fortified by a great accumulation of stratigraphical and lithological evidence, to the old conclusion that the Green Mountain range represents an anticlinal axis of primitive schists, as shown by Amos Eaton in his engraved sections published in 1824, and again in 1832, and constantly maintained and taught by him and by Ebenezer Emmons.

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[3] "Quant aux roches cristallines qui forment les Montagnes Vertes dans la province de Quebec elles seraient d'après Sir William Logan des couches paleozoiques alterées faisants partie de la groupe de Quebec. M. Selwyn croit devoir dire cependant que les récherches recentes de la Conmission Géologique du Canada ont confirmé la justice de la vue soutenue depuis quelques années par M. Sterry Hunt. Ces roches cristallines semblent donc appartenir à unterrain plus ancien que les couches fossilifères du groupe de Québec etprobablement forment l'équivalent du terrain huronien." Mr. Selwyn, having spoken in English the thanks of the president were given to Mr. Ch. Barrois who thus résumed them in French (loc. cit. pp 233—234.)

Having thus disposed of the question of the age and structure of the Green Mountain range we come to the more particular history of the uncrystalline sediments, of the vicinity of Quebec, as seen in the sections of Sillery, the island of Orleans and Pointe Levis. Whether referred to the Second or later to the First Graywacke, whether called Hudson-River group or Quebec group, the apparent succession, as described by Logan in this typical region, was assumed to be the true one. The massive and apparently overlying sandstone of Sillery was declared to be the newest and the Levis division the oldest of this great series of strata. From many years of careful study of this vicinity, and of other out-crops of the same rocks elsewhere, I was however led to an opposite conclusion, which so far as I am aware was first set forth in 1872, when it was said: "If, as I am disposed to believe, the southeastward-dipping series of the older strata near Quebec exhibits the northwest side of an overturned and eroded anticlinal, in which the normal order of the strata is inverted, then the Lauzon and Sillery divisions which there appear to overlie the Levis limestones and shales are older rocks, occupying the position of the Potsdam, or of still lower members of the Cambrian." Billings in a private communication to me in 1876, a little while before his death, expressed his approval of my view, which was in accordance with his paleontological studies.

The same view was again set forth in a note on The Quebec group in Geology, read before the Boston Society of Natural History, October, 1876. (Proc. xix pp. 2-4.) Therein it was explained that the series of rocks to which Logan had given that name near the city of Quebec have a measured thickness of over 5000 feet and dip at a high angle to the southeast. "The whole was described by Logan as having originally occupied a position *conformably* beneath the Trenton limestone of the vicinity, and as having been brought to the surface by a great break and uplift of the strata. The speaker however showed in 1871-1872, that this fault was imaginary, and that the Quebec group really occupies a position *unconformably* beneath the Trenton; moreover that the series near Quebec is inverted, being probably the northwest side of an overturned anticlinal, so that the Sillery is in fact the oldest member of the series, and was followed by the Lauzon and the fossiliferous Levis limestone, to which succeeded the graptolitic shales, the newest portion of the Quebec group." He then referred again to the testimony of Billings as to the greater antiquity of the few organic forms (*Obolella* and *Lingula*) found in the Sillery. After discussing at some length, by the help of numerous sections and by comparisons, the relations of the Cambrian rocks of Great Britain and of Scandinavia to the so-called Quebec group, "it was urged that the name given by Logan to this group should be rejected as misleading, although that of Levis, as designating a horizon of fossiliferous strata of Tremadoc age, might be advantageously retained in American geology, care being taken to distinguish it from the Quebec graptolitic zone."

The faunal relations of this group of strata I have discussed more at length in Report E of the second geological survey of Pennsylvania, where it is said: (p. 112.) "The great continental belt of rocks originally designated Hudson River group, and subsequently called Upper Taconic and Quebec group, has already afforded us at least three distinct faunas: 1. That of the Red Sandrock or so-called Lower Potsdam; 2. that of the Levis limestone, and 3: that of the Phyllograptus shale of Quebec." Still another fauna is found in certain black slates at Farnham, Quebec, at first referred by Logan, from their apparent infraposition, to the Potsdam, being "at one time conceived to underlie the whole Levis or Orleans section, and were still placed near its base. From their fossils however, these slates belong to a horizon above that assigned to the Quebec group, and correspond to the Trenton or the still higher members of the Champlain division." [*loc. cit.*, pp., 116, 119.] Further south, in the Hudson valley, within the apparent limits of the so-called Hudson-River group, are other areas of similar strata of Ordovician age, carrying the fauna of the Loraine shales and thus affording a certain justification for the frequent use in times past of the name of Hudson River group as synonomous with Loraine shales. The area of Silurian rocks at Be-

craft's mountain, near the town of Hudson, and other related cases, must not be forgotten.

When geologists abandoning the hypothesis of Mather recognize the fact that in the area mapped by him and his disciples as belonging to the Hudson-River group, there exists a great development of more or less fossiliferous strata alike of Cambrian, of Ordovician and, more rarely, of Silurian age,—that the Cambrian strata are greatly disturbed so that their real succession has been frequently misunderstood—and moreover that they are overlaid, unconformably by Ordovician strata, which were affected by later movements, and in the local absence of the massive Trenton limestones are often confounded with the subjacent Cambrian, some of the confusion which now perplexes workers in that region will be removed.

The weighty testimony of James Hall in this connection in 1862 should not be lost sight of. Referring to the evidence of organic remains then recently found in the Hudson-River slates in Vermont and Canada he remarks that they "prove conclusively that these slates are to a great extent of older date than the Trenton limestone" adding that "the occurrence of well known forms of the second fauna—*Leptæna sericea, Orthis testudinaria, Asaphus* (*Isotelus*) *Trinucleus*, etc.—in intimate relation with and apparently constituting a part of the series along the Hudson river, requires some explanation. Looking critically at the localities in the Hudson valley which yield these fossils we find them of limited and almost insignificant extent. Some of them are at the summits of elevations which are synclinal axes * * * * where the remains of newer formations would naturally occur. Others are apparently unconformable to the rocks below, or are entangled in folds of the strata, * * * * while the enormous thickness of beds exposed is almost destitute of fossils." The graptolites of the Hudson valley "which have hitherto been referred to the age of the other fossils found in the small outliers, or to the second fauna, in reality hold a lower position and belong to the great mass of slates below." Inasmuch then as the Hudson-River strata in their typical localities are, as a body, older than the Trenton limestone, which is itself older than the Loraine shales and the shales and sandstones of Pulaski "the term Hudson-River group can not be properly extended to these rocks, which on the *west side* of the Hudson are separated from the Hudson-River group proper by a fault not yet fully ascertained."[4] In subsequent examinations of the region by Logan and Hall conjointly a narrow belt of Loraine shales was traced along the *east side* of the Hudson to a point a little above Hyde Park where the boundary between the two formations crosses to the west bank, and the rocks of the older series thence occupy both sides of the Hudson down to the Highlands. (Azoic Rocks, pp. 120-121.)

In concluding the note of 1876, cited above, it was said "the author many years since pointed out that the fossiliferous Levis strata near Quebec hold in their conglomerates pebbles from the crystalline Huronian rocks which were described by Logan as altered Levis and Lauzon rocks. These crystalline schists were by Logan maintained to belong to this horizon because they are in some places overlaid by Sillery sandstone, but inasmuch as it now appears that the Sillery is really the lowest member of the Quebec group, it is clear that these crystalline schists must belong to a more ancient series."

It is to be noted that while the Second, or what we may call the Ordovician Graywacke, has for its lower member the Utica slate overlaid by the Loraine shale and terminated by the massive Oneida sandstone and conglomerate this order is reversed, in the First or Cambrian Graywacke, the Upper Taconic as defined by Emmons, a massive sandstone there forming the base of the series. For the rest, the general lithological resemblances between the two Graywacke series are such that as we have seen, Emmons from the apparent stratigraphy of the Quebec section was at first led to refer it to the Second Graywacke, a determination accepted without hesitation by Logan, who shared in the general mistrust and disfavor shown to the later conclusions of Emmons until convinced at the end of 1860 that the contention of the latter with regard to the Upper Taconic was true. Meanwhile, accepting the metamorphic hypothesis of Mather, which maintained the transformation of the Levis and Lauzon sedimentary strata into crystalline schists, the small amounts of oxyds of titanium, chrome and nickel, of magnesian silicate (and even the distinct portions of serpentine) found in certain beds of the Sillery division were explained as due to the penetration of a mysterious process of metamorphism into the superior member of the sedimentary series, rather than to the accumulation of detrital matters from the older crystalline schists in the basal member of a new and unconformable group of uncrystalline sediments.[5]

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[4] See Geology of Wisconsin, 1862, p. 443, cited in the author's report on Azoic Rocks, E., Second Geological Survey of Pennsylvania, page 118.

Park Avenue Hotel, New York, March 1, 1890.

THE MAKING OF PENNSYLVANIA.

By E. W. Claypole, Akron, O.

Part The First.

The beautiful Keystone State has a long and eventful history. Ages before her bell tolled forth the birth of a nation —ages before her Quaker Patron landed on the shores of the Delaware, negotiated his bargain for cheap land with the native tribes and founded the city of brotherly love—ages before the yet earlier Swedo-Finnish colony settled at the meeting of the two streams—even long ere the Red Man or that other and earlier race whose remains are found in the gravels of New Jersey had come upon the scene, the "Making of Pennsylvania" began. The story of her development from the most distant date yet discernible by the telescope of geology to the commencement of her occupation by man, though at present a mere outline, is yet of great interest not merely to the geologist but to every one who feels any curiosity regarding the processes— by which the earth of to-day has been evolved.

The geological history of Pennsylvania divides itself into two great eras—the palæozoic and the post-palæozoic. These may be defined for our present purpose as the eras before and after the end of the Carboniferous period. The cessation of the coal-making process on a grand scale was their dividing epoch.

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[5] Those who wish to study the present question will find besides the two papers from the Proc. Boston Soc. Nat. History in 1870 and 1876, already cited, much additional matter in the author's address before the Amer.Assoc.Adv.Science, at Indianapolis in 1871, on The Geognosy of the Appalachians, and in his essay on the History of the names Cambrian and Silurian in Geology, in the Can. Naturalist for 1872. The latter appeared in a French translation by Dewalque, at Mons, in 1875, and both are reprinted in the author's Chemical and Geological Essays. See also the history, with much detail, in Azoic Rocks, being Report E., of the Second Geological survey of Penn., 1878, and further Geological History of Serpentine, with studies of pre-Cambrian Rocks, Royal Soc., Canada, Vol. I., and The Taconic Question in Geology, *ibid*, Vols. I. and II.; both being reprinted in the author's Mineral Physiography and Physiology. Further, the Taconic Question Restated, American Naturalist, Feb., March and April, 1887.

The two volumes in which are recorded the annals of these eras contain all that we at present know regarding the story of Pennsylvania. There may be, indeed there probably is, a yet earlier volume, a pre-palæozoic one, but it is not yet published, its materials are not yet collected, and it cannot therefore be considered.

In the earlier of the two volumes above mentioned we read accounts that reveal a condition of things so different from any now existing that the "oldest inhabitant" of the State may be pardoned for failing to recognize his home. If we could restore palæozoic Pennsylvania with any approach to exactness we should have a series of successive geographies changeable as the views in a kaleidoscope. No one of these would in the least resemble the state as it now exists, but it would be possible to trace a process of evolution running through them and to discover some of its results even in the present topography.

The palæozoic age was long, very long, longer doubtless than all the time that has elapsed since it ended and in so vast an era it is of course impossible to present details. Still less is it possible to give at one view more than the merest outline. It must suffice to indicate in general terms what was going on in the region during the millions of years that flowed by as the period passed.

If with the aid of the telescope of geology we try to sight across this long time-interval and realize or fill in the dim outlines of the picture that is brought before our mental eye from that far-off horizon we behold the water of a sea covering the greater part of what is now Pennsylvania. These waters were part of an immense Palæozoic Mediterranean whose northern boundry was along the Canadian Laurentides, its western somewhere in the region of the RockyMountains and its southern altogether unknown. Its eastern coast as nearly as can be determined lay long the line of the gneissic area in the southeast of the state for the most part, through Philadelphia, Chester, Lancaster and York counties.

But the geologist does not pretend to lay down this coastline with exactness or definiteness. The view is so distant and interrupted by so many intervening obstacles that only the main features are traceable. He cannot tell how large was the mass of land whose outlines formed the coast whether it was continuous or archipelagic, high or low. Some have thought that they could make out a vast continent extending into what is now the Atlantic ocean. Others fail to see more than a narrow strip of land ending eastward nearly at the existing coast. Some picture high mountain ranges that have been since destroyed by erosion. Others see only a low tract more or less cut up into islands of gneiss and schist and slate.

What we do know is that the bottom of this sea of Pennsylvania above mentioned was slowly subsiding during the whole palæozoic era, not continuously but intermittently, as the wreckage washed off the adjoining land was dropped into it by rivers and currents. Such subsidence under increasing load is a common occurrence. It is now happening at the mouths of the Ganges and the Mississippi. Its frequency has supplied a strong argument to those who favor the theory of a yielding crust underlaid by a liquid or viscous stratum. But be this as it may the fact remains that a region of great deposition is usually a region of continued subsidence and if in the present case the proof be demanded it is readily forthcoming. In the immense mass of sediment laid down in the palæozoic sea of Pennsylvania we find indications of shallow water in ripple marks, mud-cracks &c.,and as these occur at almost every level through the whole five or six miles of rock that compose the deposit it is evident that every such layer was at the time of its formation within reach of surface action.

Probability not less than evidence indicates that then, as occurs now, the marginal coast-line rose as the sea-bottom fell and that thus there was a continuous renewal of the quarry from which material could be cut by erosion and of the pit into which it could be thrown.

We may then picture to ourselves all the northern, central and western parts of the state in the early palæozoic period under the waters of a slowly deepening sea and the southeastern corner as a slowly rising area of land. Beyond this we dare not go with confidence. What rivers washed the worn material of that land into that extinct sea, where they flowed, how large they were and what changes they underwent during their long existence—all these matters are left for the future to disclose. What rocks then constituted its surface we can do little more than guess. What forms of life inhabited that surface in the earliest time the palæontologist has not yet discovered. The land on which they once dwelt is gone and the marginal beds have thus far yielded no trace of any remains that chance may have washed into them. All is blank.

This land area remained above the water, doubtless with great variation from time to time, throughout the whole palæozoic era and afforded, in part at least, the material that went to build up the enormous sediments of middle Pennsylvania. If total submergence occurred it was neither long nor permanent and all evidence of it fails. Successive maps, could they be constructed, would show much change of detail but the Palæozoic Coast Survey has not yet begun its labor, has not indeed been appointed and it would be foreign to our porpose to encumber this sketch with minute and speculative details.

The Ordovician (Lower Silurian) era passed away with all its minor divisions of Calciferous, Chazy, Trenton and Hudson River groups and at its close there was a prophetic manifestation of Earth-force which outside of Pennsylvania forced up the newly deposited strata in western Ohio into a wide anticline extending from southwest Ontario to Tennessee now known as the Cincinnati arch. Rising above water it formed an island in the palæozoic sea which existed for a long time, till sharing in the general subsidence it ultimately sank and was covered with the later deposits of Silurian and Devonian sediments.[1]

Though it is usually considered that this manifestation of Earth-force failed to leave any discoverable impress on the geology of Pennsylvania yet it is somewhat doubtful if this opinion is well founded. Certain signs in the southeastern part of the state betray at the close of Ordovician time an epoch of disturbance of considerable extent and importance. A glance at the map shows that these rocks extend much farther in that direction than do any of the succeeding palæozoic strata. Though the exact age of the great limestone ranging through York, Lancaster and Chester counties is somewhat uncertain, yet there can be no reasonable doubt that it is of early palæozoic date. It may therefore be taken as evidence that the early palæozoic sea extended over that area. The absence of every sign of later rocks is at least an indication that they were not deposited and therefore that later seas did not cover that part of the state. The existence of the South mountain as a barrier between these two areas may be quoted as an additional argument in the same direction. The onset of a time of enormous erosion of siliceous material whose only discoverable origin, though now altogether effaced by erosion, must lie somewhere in this region and its deposition as the massive Medina sandstone again points to an elevation of this portion of the state in mid-palæozoic days accompanied with a certain amount of folding and crumpling. It is not necessary to maintain that the existing South mountains are of that age though this is by no means impossible. Their apparently Cambrian strata have suffered enormous erosion and the axis now surviving even if of later elevation, is but a fragment of the mass that once existed. This range may be coeval with the Green mountains of Vermont and be due to the southward extension of the same compressing force. Both may have stood above the water from mid-palæozoic time to the present day. Both bear all the marks of immense antiquity.

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[1] It must not be inferred from this general remark that this submergence was continuous. Probably the Cincinnati Island existed intermittently during the whole later palæozoic era. At times it was covered with water and at others dry. In the Hamilton period for example it was probably dry while in Corniferous and Huron ages it was apparently submerged.

If this view is correct we have proof in Pennsylvania of a paroxysm of disturbance before which the rise of the Cincinnati arch in Ohio sinks into complete insignificance. The massive South mountains then become the relics of its elevation and the Medina sandstone 2,000 feet in thickness a monument to its energy and extent. But the palæozoic geography was not essentially changed. Sea and land on the whole still occupied the same areas.

We can pass rapidly over the remainder of the palæozoic era as it was unmarked by any epoch-making events. The formation of sediment and its deposition in the Pennsylvanian sea continued through the whole Devonian era. On the top of the Ordivician were laid down the Medina sandstone, the Clinton and Onondaga shales and the Lower Helderberg limestones. On these followed the Devonian system consisting of the Oriskany sandstone, the Corniferous limestone and the thick shales of the Marcellus, Hamilton, (which includes a massive sandstone in middle Pennsylvania), Genesee, Portage and Chemung. The indications of slight or temporary changes of level during this long succession, though of much geological interest, must not detain us here. But the immense thickness of these rocks combined with the fineness of their material enables us in some degree to realize the enormous lapse of time required for their deposition.

A change then ensued in the nature of the sediment. The deposit of fine mud was succeeded by the inbringing of sand, and the Catskill or Upper Devonian strata were laid down to the thickness of 8,000 to 10,000 feet. There are strong reasons for believing that these red rocks were formed not in a marine but in a lacustrine or aestuarine area and that some geographica change had taken place which is as yet unknown but which had the effect of cutting off that free communication with the open sea that had previously existed. Then followed the Pocono sandstone 2,000 feet in thickness, the Mauch Chunk red shale 1,500 feet, and the Carboniferous Conglomerate of about 1,000 feet on the top of which the coal beds were formed in succession consisting of alternating strata of shale and coal with few limestones and indicating fresh water or marshy conditions during a great part of the time.

The long Appalachian subsidence was still continuing, but apparently the supply of sediment from some new source enabled deposition to keep pace with it and during the Carboniferous era we find evidence of alternating conditions. At one time the sea which had survived in the southwest, in Indiana, in Illinois, Missouri and Tennessee,extended into the southern and western counties of Pennsylvania, depositing marine limestones and marine shells. Then fresh water resumed the area and even dry land supported a rich and varied vegetation. Anon these were buried beneath a deluge of sand or mud. Again the ground became dry or swampy and coal plants flourished. Subsidence prevailing brought in the sea from the southwest and a limestone was the result. Thus the process continued until a heterogeneous mass of strata was deposited ranging from 10,000 to 14,000 feet in thickness. The picture of the Keystone state during this time is one that requires much thought and trouble to realize. The constant and long succession of changes implies not only a long time but a condition of instability now unknown. The flow of streams or seas of apparently fresh water bearing enormous quantities of sand and burying beneath it the vegetable growth over thousands of square miles is difficult to imagine and the repetition of this over and over again to form the many beds thick and thin that compose the coal fields of Pennsylvania indicates an oscillation of level quite beyond the range of our experience. Yet at the time in question such seems to have been the condition of things over the whole state and even far beyond its limits. The massive anthracites of the East, the semi-bituminous coals of Blossburg and Broad Top and the soft but inexhaustible fuels of the West all agree to tell us the same story of the time of their deposition, when for thousands and tens of thousands of years the whole middle and western part of the state was one vast coal-growing swamp of varying rankness and luxuriance but each part contributing its share to the production of this staple of Pennsylvania.

To one familiar with the state or even well acquainted with its map the above description of it during the Carboniferous era may sound extravagant. Knowing the small area to which the coal-fields are limited he may be surprised to hear of the prevalence of coal-making over so great a region. But probability leads us to the belief that these conditions prevailed wherever the later palæozoic sea had spread within the state. The present isolated coal-fields of Pennsylvania were probably once connected and a vast series of coal-swamps existed from the most easterly point where coal is now found across the state to the west, forming a store of mineral fuel compared with which even her present liberal supply is insignificant. This point will be better appreciated when the process of rock-destruction has been considered.

The end of the palæozoic era was now approaching and geology to our eye reveals the state of Pennsylvania as one dismal, trackless, impenetrable maze of low lying land, of swamp and morass, of pool and lake, clad with an obsolete vegetation and tenanted by animals whose highest types consisted of a few reptiles and amphibians. No mountain or even hill broke the monotony of her western and central flats and if rivers drained them, as they probably did, they wound along slow and almost stagnant, in for the most part a south or southwest direction. Subsequent changes have, however, so completely effaced their channels that it is quite impossible now to reproduce the hydrography of Pennsylvania as then existing with any degree of certainty. The Appalachian Revolution, as Prof. LeConte has happily termed the great change next to be described, was at hand and its iconoclastic zeal entirely destroyed nearly all traces of pre-existing conditions When it was over, Pennsylvania started on a new career of existence.

The Revolution was on this wise: The Earth-force which in earlier days had shown signs of its intensity again manifested itself. The vast system of low lands, marshes, pools and rivers that we have just described and the massive palæozoic sediments on which they rested, many thousands of feet in thickness, began slowly to yield to its energy. This force, whatever its nature, was exerted from the southeast and in a horizontal direction. But it was irresistible. Before it the solid and massive palæozoic deposits from three to seven miles in thickness, yielded as a spread table cloth before a pressing hand and rose in gigantic waves or sank in huge furrows at right angles to the direction of pressure. Stiff as these beds were their stiffness availed them nothing; heavy as they were their weight was as that of a feather before the incalculable Earth-force. Their stiffness and their weight were as vanishing quantities when compared with the thrust that came to bear upon them. Arch behind arch slowly arose, trough after trough as slowly subsided until the whole central part of the state, previously flat and monotonous, became one complicated system of ridges and furrows where horizontality was almost unknown. The greatest intensity was felt in the southeast where consequently the arches are steepest. Gradually their abruptness grows less to the westward and their steep slopes flatten down until they disappear. So severe was the pressure at the place of onset that not a few of the anticlinals are actually overthrown, their tops having been pushed beyond their bases so that both sides slope in the same direction. Thus in the Cumberland valley the successive waves are so overthrown and pinched together that there is only one continuous dip varying from 50 to 80 degrees across the whole limestone outcrop between the South and the Blue mountains.

The intense compression to which this part of the continent was subjected is sufficiently proved by the distorted condition of the strata. But another consequence is equally inevitable though seldom brought forward. Such crumpling as above described can not have occurred without the wholesale transfer of large areas of the state from one place to another. The folding of the strata in the west lessened their horizontal extent and with every succeeding anticlinal to the east this shortening of area became greater so that the previous swamp was not only thrown into a series of ridges and furrows but these ridges and furrows were crowded against one another until the whole mass of the southeastern arches was shoved bodily forward to the northwest over the deeper rocks below it. Careful computation made some years ago by the writer showed that the line from a point in Blair county to a point in Cumberland county,crossing eleven of the mountain ranges and the Great Valley and now only 65 miles long represents a line about 153 miles long before compression took place. Or, quoting from the paper alluded to:—

"During the compression and corrugation to which the mountains of Pennsylvania owe their origin the southeast line of Huntingdon county was moved forward two miles, that of Mifflin four miles, that of Juniata six miles, that of Perry nine miles and that of Cumberland eighty-eight miles. Consequently the whole of Mifflin county was shoved at the least two miles to the northwest, the whole of Juniata county four miles, the whole of Perry county six miles and the whole of Cumberland county nine miles, over the underlying deeper strata. The movement of course diminished toward the northwest in consequence of the increasing resistance offered by the increasing load and came at length to nothing beyond the limits of Pennsylvania. Ohio was the great buffer-plate against which this tremendous Earth-force spent itself. The southeastern portion of the district—the Cumberland valley—and even probably some considerable area beyond it to the southeast felt its first and mightiest pressure. There the strata were crumpled, bent, crushed and thereby thickened till it became easier to shove them bodily forward than to bend them again. They were consequently added as a snow-plow in front of the mighty engine and in their turn communicated the movement and the crumpling to the northwestern country beyond them."[1]

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[1] "Pennsylvania before and after the elevation of the Appalachians." American Naturalist, March, 1885.

Mass motion to this extent and of this nature is, I think, seldom realized as an actual occurrence. But if it is real as above shown—if strata have slidden bodily over strata for miles, and whole counties have been shoved for long distances out of their previous places over "thrust-planes" lying almost horizontal, it is obvious that great lateral displacement must be recognized as an important geological factor in disturbed regions. A striking illustration may be found in the very area now under consideration. During the Appalachian Revolution or that earlier one in mid-palæozoic days the folds composing the South mountain chain actually snapped across under the strain, and one part—the northeastern—was shoved forward three miles beyond the other—the southwestern. This cross-fracture and thrust may now be recognized in a notch of that extent in the mountain-wall of Franklin county near Chambersburg.

How long these stupendous changes occupied it is of course impossible to tell, but there are reasons for believing that they were not sudden or catastrophic. They probably progressed slowly so that the surface was not much disturbed and they may have occupied the whole of the long interval between palæozoic and mesozoic time, or even a longer period. This, however, does not now concern us. We have shown that the great sea of Pennsylvania was converted into a swamp and flat, and that on this swampy flat huge arches of bent strata were reared to a hight that it is difficult now to realize. It remains to show how from this complex of arches the modern Pennsylvania has been slowly constructed as mesozoic and tertiary time passed by. In other words we may here close the first volume in the history.

EDITORIAL COMMENT.

AWARD OF THE HAYDEN MEMORIAL MEDAL TO PROF. JAMES HALL, LL.D. The widow of Dr. Ferdinand V. Hayden, late Director of the U. S. geological survey, executed two years ago the following deed of trust, to which is appended the official acceptance of the same by the designated trustee:

Know all men by these presents that I, Emma W. Hayden, of the city of Philadelphia, in commemoration of my dearly beloved husband the late Ferdinand V. Hayden, LL.D., and to perpetuate his name and for and in consideration of the sum of one dollar, lawful money of the United States of America, have assigned, transferred and paid over unto the Academy of Natural Sciences the sum of two thousand five hundred dollars, in cash, to be known forever as the "Hayden Memorial Geological Fund" in trust to hold the same upon the following uses, intents and purposes, that is to say in trust to hold the same and to invest and keep the same invested in such securities as are allowed by law for the investment of trust funds in Pennsylvania, such investments to be kept separate and apart from the other funds and investments of said Academy and to receive and collect the interest and income therefrom derived as the same shall accrue and to apply such interest annually, together with a bronze medal of such cost and design as the hereinafter mentioned committee shall designate which shall be purchased thereout, as a reward for the best publication, exploration, discovery or research in the sciences of geology and paleontology, or in such particular branches thereof as may be designated, which award and the conditions and limitations attending the same and all matters connected with this gift shall be determined by a committee to be selected in an appropriate manner by the Academy.

In witness whereof I have hereunto set my hand and seal in duplicate the eleventh day of April, Anno Domini 1888.

EMMA W. HAYDEN. (Seal.)

Sealed and delivered in the presence of
H. H. DIGOTT.
CARL ROYER.

The Academy of Natural Sciences hereby accepts the trust in the above deed set forth and acknowledges to have received from Mrs. Emma W. Hayden the sum of two thousand five hundred dollars therein mentioned.

Witness the corporate seal duly attested this fourteenth day of April Anno Domini 1888.

JOSEPH LEIDY, President A. N. S. (Seal.)

Attest:
EDW. J. NOLAN, Rec. Secretary A. N. S.

The committee appointed by the president of the Academy of Natural Sciences consisted of Prof. Joseph Leidy, M.D., LL.D., etc, chairman, Prof. J. P. Lesley, Prof. Angelo Heilprin, Prof. Wm. B. Scott, and Dr. Persifor Frazer. This committee was called together a few weeks ago and presented the following report:

TO THE ACADEMY OF NATURAL SCIENCES. The committee appointed by the Academy of Natural Sciences to recommend the award of the Hayden memorial medal for the most important contribution to the science of geology, has the honor to report to the Academy that it has selected Prof. James Hall, the state geologist of New York for the honor of receiving the first award of this medal. In making the selection the committee feels confident that it will have the endorsement of every geologist both here and abroad, but it deems it due to the eminent character of the recipient of this medal, and of the work which he has done for fifty-eight years and is still doing for science that these services should be here formally acknowledged.

Prof. Hall was born at Hingham, Mass., on Sept. 12th, 1811, and is therefore now in his 79th year. He commenced his scientific life in 1832 when, after graduation at the Van Rensselaer Polytechnic School, he immediately assumed the duties of a professor there. His dedication to the special branch of research to which he has made so many and important contributions, began in 1836 when he was appointed professor of geology at this institution and the same year one of the assistant geologists on the then just instituted geological survey of New York. In 1837 he was made state geologist in charge of the "fourth division" of the state. His final report of this district was made in 1843, and thence with the title of state geologist he was placed in charge of the paleontological work. From then till 1879 five volumes of the paleontology of the measures from the Potsdam sandstone to the base of the Coal Measures have been issued. He has prepared a complete revision of the paleozoic brachiopoda of North America which is now in press and which has necessarily required researches as far west as the Rocky mountains.

He was also state geologist of Iowa in 1855. In 1867 he was elected state geologist of Wisconsin. He has besides prepared monographs on the graptolites of the Quebec group (1865); two volumes of the geology and paleontology of Iowa (1858-9); the chapters on geography, geology and paleontology of Wisconsin in 1862; Fremont's exploring expedition, Appendix A, (1845); Expedition to the Great Salt lake (1852); U. S. and Mexican boundary survey (1857); U. S. geological exploration of the 40th parallel, vol. IV. He has published volumes of reports of progress ever since 1866 when on the reorganization of the N. Y. State Museum he was appointed director as well as state geologist. Notable among these are Vol. VI, on the Corals and Bryozoa from the Lower and Upper Helderberg, and Hamilton—Vol. VII containing descriptions of the trilobites and other crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill, (in fact, eleven volumes in all). He received the grand cross of the order of St. Maurice and St. Lazarus from the king of Italy in 1882, and the Walker quinquennial grand prize of $1,000 from the Boston Society of Natural History in 1884.

He is the only surviving founder of the American Association of Geologists which was organized in Philadelphia in 1840 and out of which grew the A.A.A.S. He was one of the charter members of the National Academy of Science, and one of the original founders of the International Congress of Geologists, at all sessions of the latter which he has attended having been elected vice-president representing the United States. He was elected the first president of the recently organized Geological Society of America.

He was elected one of the foreign members of the Geological Society of London in 1848 and received its Wollaston medal in 1858, and he was elected correspondent of the Academy of Sciences of Paris in 1884.

Probably no one living has influenced to a greater extent the domain of invertebrate paleontology, and much of the exactitude of knowledge which his researches have introduced into the New York reports have made these the standard of geological nomenclature and classification throughout America.

In this connection a fragment of the history of the relations between Hayden and Hall is interesting.

In 1851 on Prof. Hall's return from a successful geological exploration of the upper lakes and the Mississippi valley he called upon Dr. J. S. Newberry at Cleveland, Ohio, and was introduced to a young man in the latter's office who had made some interesting collections in the limestone at Sandusky and the neighboring country. This young man was Ferdinand V. Hayden. His zeal and industry impressed Prof. Hall and his great desire to undertake explorations and the collection of fossils prompted the New York geologist to encourage him in this purpose. The region of the "Mauvaises Terres" then so new and deeply interesting was spoken of and Hayden was asked if he had the courage to undertake an exploration to that region, which he answered affirmatively. During that winter it was arranged through correspondence that Hayden was to start in the early spring going up the Missouri in the first steamboat of the season. Some difficulties arose at St. Louis through another exploring party of which Prof. Hall had not known, and the latter sent Mr. F. B. Meek, at that time an assistant and draughtsman in his office at Albany, to accompany Hayden. This was Dr. Hayden's first expedition.

The collection of fossils brought down was a very good one and they have all passed under Dr. Leidy's scrutiny (some of them having been illustrated by him) and are now in the New York Museum of Natural History in New York city. It is unusual that the man who first gave aid and encouragement to a beginner should live to receive the award of a medal founded in honor of the latter.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The geology of Ontario, with special reference to economic minerals. By ROBERT BELL, B.A.Sc., M.D., LL.D., member of the Royal Commission on the mineral resources of Ontario. Toronto. pp. 57. (From the report of the Royal Commission). This report consists of a concise general review of the geology of Ontario, specially enumerating the mineral productions that have attracted attention and the possibilities of further development. Below the drift are enumerated the Devonian, Silurian, Cambrian, Huronian and Laurentian, with their subdivisions. Their geographic areas are described, and their economic resources, employing the names of the formations that were applied by the New York geologists. Dr. Bell has personally visited and examined very many of these mineral deposits, and his descriptiens have, therefore, the value and accuracy which belong to the work of an experienced geologist.

The crystalline rocks are embraced under the term *Azoic*, and are divided into Huronian and Laurentian, each with an "upper" and a "lower" portion. Above these are what Dr. Bell calls Cambrian, containing the Animikie, the Nipigon and the Potsdam. The greater portion of the developed economic minerals of Ontario are contained in the Azoic and Cambrian.

The Lower Laurentian is apparently barren of metallic ores, but the anorthosites, and the gneisses and limestones of the upper series, (the equivalent of the gabbro and the Mesabi gneisses in Minnesota) contain a considerable variety of them. Here are mentioned iron ores, graphite and apatite; but no localities are given where these minerals are mined in the Upper Laurentian.

In the "Huronian" as defined, including all the rocks from the Laurentian to the fossiliferous strata of the Primordial, are found by far the most of the economic mineral products of Ontario, and Dr. Bell styles this the *metalliferous series*. Here are mentioned some localities that promise to be valuable as iron producers. These are mostly north of lake Superior, and are thought to be associated with the same rocks as those of Tower. Dr. Bell has fallen into a misapprehension, however, respecting the iron ore north of Gunflint lake. It is found near the bottom of the Animikie, whereas that of Hunter's island is in the Keewatin, and is in the direct line of strike of the rocks from Tower.

Copper and nickel are described at Bruce and Sudbury, and that at Sudbury is supposed to be in the northwestern extension of the rocks that contain the copper and nickel of the old Wallace mine near the shore of lake Huron, and similar nickeliferous copper has been observed at numerous points intervening.

Recent discoveries of gold are announced. The Huronian mine is in the township of Moss, and the gold is found free and as sylvanite (or telluride of gold) associated with galena, iron and copper pyrites and blende. This is in a quartz vein, and the country rock is a "talcoid chloritic, dioritic and a little dolomitic schist," with siliceous magnetite and massive dioryte. This is the usual manner of occurrence at the other numerous places mentioned in the report. Yet in one instance, on lake Wahnapitae, it was found in narrow quartz veins cutting a highly feldspathic reddish quartzyte resembling fine-grained granite, but distinctly elastic. In this respect this deposit resembles that of the famous Treadwell mine on Douglass island, Alaska, as described by Dr. Geo. M. Dawson and Mr. F. D. Adams in this journal.* In general the gold of Ontario seems to be embraced in the same (Keewatin) formation as the mines of Michigan near Ishpeming.

In the same formation are described briefly some unimportant discoveries of silver and some of argentiferous galena; zinc, antimony, arsenic, tellurium, platinum, tin, molybdenum, bismuth and cobalt have also been found in Ontario in small quantities.

In the Animikie formation are the great silver mines of Ontario northwest of lake Superior. Here silver occurs native, in grains, threads and small branching forms, and as argentite in leaves and small masses, but occasionally in large crystalline lumps, as at the Rabbit Mountain mine. Huntilite and animikite, two new silver compounds, were found some years ago at Silver Islet, near Thunder bay in the great Silver Islet mine. This mine has been worked to the depth of 1230 feet, the work continuing up to the beginning of 1884, the value of the silver extracted having been $3,250.00. The vein in the part worked was from 8 to 10 feet in thickness, but in some places measured 20 or 30 feet. The vein, which is one of quartz carrying, along with free silver, galena, blende and graphite, runs N. 32° W. across Burnt island and on to the main shore, crossing a dike of diabase trap. The silver was found only in and near the trap. Graphite was present in the richest parts of the vein. Hydrocarbon gas and water holding chlorides of sodium, calcium and magnesium were struck in the deeper workings of the mine. Graphite and inflammable gas have since been met with in other silver mines in the district.

Small quantities of native copper have been found in the Nipigon formation on St. Ignace, Simpson's and Battle islands. But on the north shore of lake Superior it seems to be relatively scarce compared with the copper output of the mines on Keweenaw point on the south shore.

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*AMERICAN GEOLOGIST, vol. IV., pp. 84, 88.

There are many interesting geological and mineralogical facts stated in this report. On scientific principles it is rather dogmatic, even on controverted questions, but perhaps that is unavoidable in a report designed primarily not for geological students but rather for general readers and capitalists desiring general information.

Geological and Natural History Survey of Canada; Annual Report, vol. III. new series, for 1887-88. Montreal, 1889. This ponderous volume of more than 1450 pages, with 35 plates and 16 sheets of maps and sections, is published in two parts, comprising thirteen separately paged reports.

Director A. R. C. Selwyn's administrative report occupies 117 pages, summarizing the work of the survey during the years 1887 and 1888. The professional staff numbered thirty-six, with seventeen other assistants; and the appropriation each year was about $100,000. The number of visitors to the survey museum in Ottawa averaged fifty-four daily; and the director believes that the number would be largely increased by opening the museum to the public on Sunday afternoons, which he recommends. Referring to the objections urged against this, he remarks that "in the museum the *work*, and in the church and Sunday school the *word*, of the Creator is expounded.

Dr. George M. Dawson's *Report on an exploration in the Yukon district, N. W. T., and adjacent northern portion of British Columbia, 1887,* fills 277 pages, and is accompanied with nine plates and two maps. The detailed map of the route traversed, amounting to 1,322 miles, is in three sheets, on the scale of eight miles to an inch. It extends from the Pacific coast up the Stikine river and across the watershed to Dease lake, down the Dease river to the Liard, thence northwestward along the Frances and Pelly rivers to the junction of the latter with the Lewes, forming the Yukon, and thence northward up the Lewes to its head in the Chilkoot pass and to Lynn Canal on the Pacific. The drainage basin of the Yukon, according to Dr. Dawson, measures about 330,000 square miles, of which the upper half, approximately, is in Canadian territory. He believes the Yukon much inferior in size to the Mackenzie, which has twice as large area of drainage, while that of the Mississippi exceeds both of these together, though sending proportionately less water to the sea.

The Coast ranges are found to consist mostly of granite and granitoid rocks, probably erupted between the Triassic and Cretaceous periods, as the author has shown for their continuation to the south, near the northern part of Vancouver island. The interior region consists mostly of Palæozoic rocks of very varied appearance, probably belonging to several subdivisions of the geological scale. Fossils of Cambro-Silurian, Carboniferous, and Triassic age are reported. Overlying the Carboniferous limestones, and partly interbedded with them, are more or less evidently stratified rocks of volcanic origin, comprising amygdaloids, agglomerates, and other more massive materials which apparently represent old lava-flows. No unconformity has been proved to occur throughout the whole of the Palæozoic series, but the examinations were not sufficient to detect any stratigraphic break unless of a very obvious character. The Mesozoic era is represented also by strata of Cretaceous and Laramie age, which rest quite unconformably on all the older formations, though they have since been to some extent involved in their flextures. A paper by Dr. Dawson on the glaciation of this district has already appeared in the AMERICAN GEOLOGIST, April, 1889.

Seven appendixes of this report treat of the fossils, plant collections, zoology, lithology, meteorology, astronomic observations, and Indian tribes.

The next memoir of this volume is a *Report on the geology of the mining district of Cariboo, British Columbia.* By AMOS BOWMAN, mining engineer; 49 pages, with maps, sections and panoramic views from mountains. Cariboo, as a political division, embraces a complete section across the northern interior plateau, from the Cascade range to the Rocky mountains, within the Fraser basin; but the portion specially surveyed lies wholly east of the Fraser river, being an area about fifty miles square, from Quesnel lake northward. This tract includes some of the richest placer mining in the world, having yielded nearly half the gold product of British Columbia since 1860, or not less than $15,000,000, chiefly from a few miles in length of auriferous drift in several valleys.

Note to accompany a Preliminary Map of the Duck and Riding Mountains in Northwestern Manitoba. By J. B. TYRRELL. (Part E, of the same report, pp. 16, with map.)

This report discusses the general physiographic features of a previously unknown portion of north western Manitoba and gives a review of the glacial and Post-glacial phenomena that have largely contributed to impress on the country its surface characters. It is divided into two distinct portions, viz: An eastern lightly sloping alluvial plain, formerly covered by the waters of the post-glacial lake Agassiz, and a western table land presenting a steep escarpment to the east and a gentle decline westward towards the present valley of the Assiniboine, in the upper portion of which a post-glacial lake, called "lake Assiniboine" is shown to have formerly lain. The mountains or table land consist in the main of Cretaceous rocks, but these are overlain by a considerable thickness of morainic detritus, in places heaped in irregular hills, thickly strewn with gneissic boulders. After the retreat of the continental glaciers towards the Archean area towards the north and east a local nevé was left on the summit of the Duck mountains which sent down glaciers into the wide valleys cut out by the floods that had rushed from the front of the receding continental glacier. Evidences of these local glaciers are left in small terminal moraines blocking the valleys.

On the alluvial plains to the east the beaches of lake Agassiz are traced northward as far as the Swan river valley in Lat. 52°, where they appear to still retain the same well marked characters of those further south in Minnesota and Dakota. The north end of lake Agassiz has not yet been reached. Its shore lines ascend northward at the rate of a foot or more per mile, the highest observed beach (near lat. 51° 50′) being at an elevation exceeding 1,400 feet above the sea, or 700 feet above lake Winnipeg. White or cream-colored Devonian limestones underlie the Cretaceous series, and are the bed-rock of the country east of the mountain escarpment.

The map is the first Canadian contour map that we have seen covering any extensive area, and serves very well to illustrate the varying slopes of the country and the position and extent of the gravel ridges.

DR. ANDREW C. LAWSON'S *Report on the geology of the Rainy Lake region*, which completes Part I of this volume, has been reviewed in the AMERICAN GEOLOGIST, January, 1890.

In Part II, MR. E. D. INGALL, mining engineer, is author of a *Report on mines and mining on lake Superior*, 131 pages, with thirteen plates and two maps. The district reported is the silver-bearing one on the north side of lake Superior between Black bay and Pigeon river. The silver ores are the native metal and sulphide or argentite generally associated with blende, galena, pyrites, etc., in a gangue of calcite, barite, quartz, and fluorite, in a series of fissure veins traversing the nearly horizontal Animikie formation. Black, soft, carbonaceous argillites constitute the upper part of this formation; while the chief character of its lower part consists in "the almost entire preponderance of siliceous rocks, such as chert and jasper, which are often accompanied by ferruginous dolomites, and themselves all contain more or less iron in the oxidized state, at some places carrying so much magnetite as to constitute almost an iron ore." All the bodies of silver ore, so far as known, occur near dykes or sheets of trap rock, and Mr. Ingall concludes that "the silver may be derived from them by decomposition of some of their mineral constituents carrying minute quantities of silver, by waters infiltrating downwards through all their joints and pores, and that these waters passing onwards and soaking into the permeable parts and minerals of the gangue in the veins, have there deposited their silver contents, the various forms of carbon present in the sedimentary rocks having had some influence in effecting precipitation."

MR A. P. Low presents a *Report on explorations in James' Bay and country east of Hudson Bay, drained by the Big, Great Whale, and Clearwater rivers*, 94 pages, with three plates. His observations of glacial striæ and transportation of boulders accord with those of Dr. Robert Bell, showing that the continental ice-sheet had a motion from northeast to southwest and west across James' bay and onward over the Archæan country that forms the watershed between Hudson bay and lakes Superior and Winnipeg. During the recession of the ice, it appears to have terminated for a long time near the middle of James' bay, its western border accumulating a moraine there, represented by a remarkable series of islands of unstratified drift. These include Charleton island and others extending a hundred miles north to the Twins and Grey Goose island, also the Bear islands, which lie nearly a hundred miles further on towards the northwest. They all rise to considerable elevations above the sea level, and are composed wholly of sand, clay, and boulders, with no bedded rocks in place, good sections of sea-cliffs being seen in many places. Fossiliferous marine beds are found overlying the glacial drift along the valleys near the mouths of rivers on the east side of Hudson bay up to the hight of over 500 feet. Since their formation, which probably took place shortly after the departure of the ice-sheet, the land has been slowly rising, with intervals of quiet, as shown by the terraces cut out of the drift along the high land of the coast.

Four appendixes contain lists of plants, of diurnal lepidoptera and coleoptera, notes of the breeding habits of certain mammals, and meteorologic observations.

Second report on the geology of a portion of the province of Quebec. By R. W. Ells. (Part K,) The area here reported on lies to the south of the St. Lawrence river, and the report deals largely with the structure and stratigraphical relations of the several divisions of the "Quebec Group." It has special interest since the geological problems therein discussed have formed a fruitful subject for controversy among geologists in Canada and the United States during the last forty years.

The present report is to some extent a continuation of that issued in 1886, in which the latest views as to the structure of the rocks of the southeastern portion of the province are expressed. These include very large areas of the crystalline schists now regarded as of pre-Cambrian age, and which in that section have a very considerable development, being the northern extension into Quebec of the Green Mountain rocks. In addition to the description of the geological formation found in the area included in the report, which on the map is known as the northeast quarter sheet of the province, further informations is presented regarding the economic resources of the district, more especially in relation to the asbestos deposits and the distribution of the serpentines in which this mineral is found. The formations described in this report are five, viz: the Devonian, Silurian, Cambro-Silurian or Ordovician, the Cambrian and the pre-Cambrian. Of these the areas of Devonian rocks appear to be of very limited extent, only two localities being known, the largest of which has an extent of only a few hundred square yards. This outcrop is on the Chaudière river, ;between the Famine river and the village of St. George; the second and smaller area being some miles further north.

These rocks contain an abundance of fossils, of which very full lists are given, which appear to represent the basal beds of the system, some of the species being common to the upper members of the Silurian as well. These outcrops appear to be the remains of a formerly extensive and wide-spread development of these rocks of this system, the greater part of which has been entirely removed.

The only rocks referable to the Silurian appear to be certain reddish shales which rest upon the fossiliferous Hudson River beds near the St. Lawrence. These are seen on the Becancour river and other streams to the north; but as the surface is largely covered with drift and outcrops of each are very rare, the limits of the basins must of necessity be largely conjectural. No fossils have as yet been found in these shales. The Cambro-Silurian includes certain shales and limestones which are the continuation to the northeast of those described in the previous report, 1886, and which are there characterized by fossils, chiefly graptolites of Trenton-Utica age. Many of the limestones of this series have been found to contain fossils often determinable by the microscope, which have also been assigned to the horizon of the Lower Trenton. In this system is also now included certain portions of the Quebec group, more especially that known as the fossiliferous Levis division, as well as a peculiar series of bituminous shales and limestones which occur in the city of Quebec and on the north side of the island of Orleans and which contain a fauna apparently of Trenton-Utica age, but in which many species, not otherwise recognized in the Cambro-Silurian sediments of the province, are found. The formations of the Trenton, Utica and Hudson River or Loraine shales which are well displayed about Montmorency Falls, Quebec, and along the St. Lawrence above that city are described and very complete lists of fossils from various localities are furnished.

Under the head of Cambro-Silurian and Cambrian is given a very full account of "the Quebec group." A summary of the various views expressed by the several writers on the subject, since the first paper by Dr. Bigsby in 1827, is presented, and the conclusions arrived at from careful study in the field by the author as to the exact stratigraphical relations of the several divisions of the group are there stated. From this it appears that the fossiliferous Levis portion, formerly regarded as the lowest member of the group, is really the upper, and that it overlies the red and green shales and sandstones of the Sillery. This is shown stratigraphically by a series of sections, first along the St. Lawrence above Quebec, between Cape Rouge and Sillery, and by sections across the rocks at Levis City, as well as at other points further inland. The evidence of the upper position of the Levis thus presented is supported by the fossils which have been collected from well defined zones, at different points, which have been determined by Prof. Lapworth and by Mr. H. M. Ami. A brief abstract of Prof. Lapworth's paper is given from which it appears that the Levis fossiliferous rocks should be regarded as forming the lowest portion of the Ordovician or

Cambro-Silurian system, while from the evidence furnished by the Levis limestone conglomerates it is evident that these rocks should be assigned, from the presence of fossils in the paste or matrix, to the Calciferous formation. These conglomerates and the associated graptolitic Levis shales clearly overlie the red and green shales of the Sillery which contain Obolella pretiosa and Lingulæ, and which are now regarded by the author as constituting presumably the upper part of the Cambrian system, though there appears to be a transition from the upper part of the red slate series into the lowest fossiliferous zone of the Levis or Ordovician as seen by the extension downward from the base of the Levis of certain graptolitic forms into the upper beds of the Sillery. The red and green shales however contain Obolella and Lingulæ which are not found in the Levis at all, and in the interstratified black shales, Dictyonema sociale and several other forms occur, which, according to Lapworth, are more characteristic of the Cambrian than the Ordovician.

Of the limestone conglomerates three fossiliferous zones are clearly recognized. Of these the lowest which is associated with the Sillery rocks, contains Olenellus thompsoni and other Cambrian forms in abundance in the pebbles but no forms newer than Cambrian. The second zone or of that of Levis is associated with the graptolitic shales of that locality. In this zone the Potsdam or Cambrian fossils are confined to the boulders, while the paste contains Calciferous species. The third is associated with the Trenton Utica beds of Quebec city.

From all the evidence presented, both from the stratigraphical standpoint and from the fossils, there is apparently no further doubt as to the relatively lower positions of the Sillery division, a point long in dispute, and which, by the present determination, renders the elucidation of the complicated structure of the interior, to the south and east, much more easy to understand.

The Pre-Cambrian rocks constitute a well defined anticlinal which traverses a large portion of the country in a north-easterly direction at some distance from the St. Lawrence. These are flanked, on either side, by certain beds of quartzite, black, green and purple slates, with small areas of limestone which are regarded as of lower Cambrian age, and which in character are precisely similar to those which flank the Green mountains of Vermont in which Mr.C.D. Walcott found his lowest Cambrian fauna. In connection with the rocks of the Cambrian system are also included large areas of dioritic and serpentinous rocks, the latter of special economic importance from the fact that they contain asbestos in quantity at several points.

The pre-Cambrian rocks consist largely of crystalline schists, chloritic, talcose and micaceous, with which are frequently associated considerable areas of green chloritic, and generally massive dioritic rocks. All these are regarded as the extension of the Sutton mountain anticlinal north-eastward, described in the preceding report. A number of sections across the series shows the anticlinal structure at every point examined and the regular occurrence of the overlapping Cambrian sediments.

The superficial geology deals principally with the occurrence of glacial striæ and the distribution of the boulders and other drift. There does not appear to be any well defined evidence of an immense ice sheet, the striæ and most of the boulders indicating merely the work of local glaciers, which were discharged apparently from the several elevations found in the area into the St. Lawrence valley on the west, and the upper waters of the St. John on the east. The presence of scattered Laurentian boulders at many points, as well as the gold drift of the interior, both of which are from north to south, are accounted for by the agency of water and drift ice, probably floes, such as are found at the present day along the lower St. Lawrence, rather than by glacier action. The presence of old pre-glacial river channels, excavated many feet below the present bed of the several streams, is pointed out. These have been filled with gravel, sand and clay, long prior to the deposition of the boulder clay, and it is from these old pre-glacial channels that the richest results in gold mining are now obtained.

A list of the fossils enumerated in the body of the report has been systematically tabulated by Mr. H. M. Ami, and forms a supplement, which presents in concise form the several localities from which these have been obtained and the zones to which they pertain.

Report of explorations and surveys in portions of northern New Brunswick and adjacent areas in Quebec and in Maine, U. S. By L. W. Bailey and Wm. M. Innis. (with map.)

In previous reports by the same authors the general topographical features of the district indicated in the title have been described as well as the lithological characters and distribution of its various rock formations. In the present report the information previously gathered is summarized and comparisons are instituted between the Silurian system as exposed in this section and in southern New Brunswick, Maine, and at various points in Quebec. The northern edge of the Silurian is followed from Gaspé peninsula to Temisconata lake, and the close correspondence in sequence of the beds exposed at the Neegette falls, Rimoriski river, Temisconata lake and at many othe points is shown by descriptions of sections at those points with lists o the fossils which each has afforded. The great area of bluish-gray, more or less calcareous slates which occupy the southern part of lake Temisconata, the Madawasha river and a large portion of the St John river is held to be probably of Lower Helderberg age and t represent the upper and more shaly portions of the Gaspé limeston series, being possibly their deep water representatives. Older portions of the Silurian as low as Niagara, or possibly Clinton, are however brought up by anticlines which occur within this area, notably a the Sagus river and on the Aristook river, Maine. Descriptions o numerous sections in the state of Maine are given with accompanyin lists of fossils, and large areas which have been described in the reports of that state as of Devonian age are shown to probably belong to the Niagara formation of the Silurian system. In a comparison of the strata of southern with that of northern New Brunswick and Quebec it is noted that the physical movements which occurred at that time resulted, in the southern area, in a general elevation which caused the upper portions of the Silurian to be but slightly, if at all, represented, while in the northern region the movements were followed by a subsidence lasting to the end of the Silurian era or beyond, during which the thick marine beds of the lower Gaspé series which include heavy layers of coral-bearing limestone, were deposited. A table is given at the end in which, for convenience of reference, the strata in the southern and northern portions are tabulated together and the correspondence between them shown. The numerous lists of fossils which are given throughout the report have been mainly prepared by Mr. Ami. The map, which is not yet issued, is promised shortly. It forms sheet No. 17 N.E. of the series of New Brunswick maps.

R. CHALMERS writes on the *Surface geology of northeastern New Brunswick*, 33 pages with two maps. Among the more important facts noted is the existence of preglacial rock debris or gravels and sands, resting on pre-Cambrian and middle Carboniferous areas, and more or less overspread with drift, from which the author concludes that the ice-sheet there had no great thickness and therefore failed to remove the whole of the pre-existing decayed rock material.

The mineral wealth of British Columbia, with an annotated list of localities of minerals of economic value, 163 pages, by DR. GEORGE M. DAWSON, is a most useful publication, reviewing briefly the physical features and geology of this province, where the author has spent many summers in field-work, and more fully relating the history of the discovery and development of its very productive mines of gold, silver and coal. During the years 1859 to 1865 over 4,000 miners worked in the gold placers, but since 1875 the number has averaged about 2,000, the yearly earnings per man varying from $1,200 to about $250. From the discoveries of the last two years, Dr. Dawson predicts that British Columbia will soon rank among the great silver-producing regions of the world. Argentiferous galenas are known to occur throughout a belt 1,200 miles long, from the international boundary to the Yukon. In coal production the province has steadily advanced to an average annual output of about 400,000 tons, three-quarters of it finding a market in California.

A report on the mining and mineral statistics of Canada for the year 1887, by EUGENE COSTE, occupies 110 pages; and *Chemical contributions to the Geology of Canada from the laboratory of the survey*, by G. CHRISTIAN HOFFMANN, 58 pages.

Systematic list of fossils with localities, &c. (Contained in the appendix to Dr. Ells' Report.) By **Henry M. Ami, M. A., F. G. S., Assistant Palæontologist to the Geological Survey of Canada.**

In a highly disturbed and faulted region such as that portion of the Province of Quebec with which the above report deals, palæontological evidence must necessarily play a very important part when the measures prove so highly fossiliferous as they are known to be, not only in determining the various horizons met with in the intercalated, faulted and isolated patches of formations occurring on every hand, but also in enabling us to recognize the sequence of strata in their proper chronological order.

Accordingly it will be seen that Dr. Ells' remarks on the geology of that district, which is the classic ground on which the famous 'Quebec group' controversy has been fought and decided, are copiously filled with lists of fossil species prepared by Mr. Ami of the Canadian Survey staff.

These lists were prepared by Mr. Ami from carefully made collections at different localities with a view to ascertain the exact relative position of the various members of that "group." This object has been fully accomplished as is shown by the lists; and except in the case of the collections from Notre Dame du Portage, St. Michael and certain districts in and around Quebec City, whence more perfect and more extensive material is necessary before a true and exact knowledge of the horizons can be obtained, there remains no uncertainty as to the true position of the strata in the other localities, of which there are thirty-six included in the Appendix.

The list comprises *one hundred and ninety* species of fossils referable to ninety-one genera and these are exclusive of forms obtained in the limestone conglomerate bands in various localities, which do not afford good evidence as to the age of the beds from which they were obtained. The *genera* and *species* noted in Mr. Ami's list are as follows:

	Genera.	*Species.*		*Genera.*	*Species.*
Spongiæ	2	2	Brachiopoda	20	49
Cœlenterata	2	3	Lamellibranchia	7	9
Graptolitoidea	22	75	Gasteropoda	4	5
Cystoidea	1	1	Pteropoda	2	2
Crinoidea	2	2	Cephalapoda	3	3
Vermes	1	1	Cirripedia	1(?)	1(?)
Bryozoa	7	8	Ostracoda	3	5

Trilobita: 15 *Genera;* 24 *Species.*

The result of the above report and the evidence which the fossil remains have afforded naturally lead to the extinction of the term 'Quebec Group,' as the various series of formations observed in the district examined have been separated into a true natural succession. The application of the terms 'Levis' and 'Sillery,' as Prof. Walcott states* in an exhaustive review of Dr. Ells' Report, to the "local development of the Calciferous terrane about Quebec" and the "passage beds and Cambrian strata of the St. Lawrence valley in the vicinity of Quebec is an admirable one," which certainly commends itself to all practical geologists who have for years been longing to see the unravelling of the mysteries of the "Quebec" as well as of the intimately allied and "Taconic" controversies.

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*Amer. Journ. Sc. Vol. xxxix, Feb. 1890, p. 114.

At the end of Part II is placed a general index of all these memoirs, each being distinguished by a letter affixed to its pagination. The whole volume presents a vast amount of well arranged information, and reflects great credit on the director and his assistants in this Survey.

On the Fossil Plants in the Ravenhead Collection in the Free Library and Museum, Liverpool. By ROBERT KIDSTON. Trans. Roy. Soc. Edinburgh, vol. xxxv, 1889, part II, No. 10, pp. 391-417, 2 plates.

Mr. Robert Kidston's memoir on the fossil plants in the Ravenhead collection is a valuable addition to the important series of comparative studies of the Carboniferous floras of which his Catalogue of the Palæzoic Plants in the British Museum (1886) was the first and an earnest of those to follow. The Ravenhead collection, from the middle or productive Coal Measures, which was made the subject of two papers by Higgins and Marrat in 1871-'72, and which is the most important collection of plants from the southwestern Lancashire Coalfield, has been twice carefully studied by Mr. Kidston, the identifications and results being now given, together with a detailed description of the local stratigraphy of the Carboniferous, in the present illustrated paper. Among the revised species it is interesting to note the identification of *Neuropteris dentata* Lesq. and *Sphenopteris mixta* Schimp., the identity of the latter being ascertained from a specimen from the Sub-carboniferous of Clinton, Mo., sent to the author by Mr. Lacoe. A number of generic changes were found necessary, but *Sphenopteris marratii* is the only new species described. Mr. Kidston is thoroughly familiar with the literature, and is painstaking in his extensive comparisons and correlations. It may be added also that he, more than any other European paleobotanist, has recognized the work of Lesquereux and Newberry in our American coal flora, and is giving more attention to the correlations of the American species with those found in the European coal fields.

Transactions of the twentieth and twenty-first Annual Meeting of the Kansas Academy of Science, 1887-88. Vol. XI. 1889, 8vo. 127 pp. Topeka.

The regular appearance of the volumes of the Kansas Academy, and their scientific value, are highly creditable to that western State, and they furnish evidence that the energetic spirit of her early settlers, in taking on the forms of a more varied pursuit has not lost its prestine vigor.

Of geological papers Prof. Robert Hay contributes one on "The horizon of the Dacotah lignite," in which he shows that this lignite is in the upper part of the Dacotah group, and not more than fifty feet below the limestone horizon, which he calls Benton limestone, although there is difficulty in distinguishing it from the Niobrara. Dr. E. H. S. Baily gives the section and some accompanying notes on the salt beds in Ellsworth county, with chemical analysis. The salt bed is 140 feet thick but is separated into two parts by a bed of gray slate five feet thick. The salt contains 96 per cent. of sodium chloride. Prof. F. H. Snow discusses the "significance of stipules in certain dicotyledonous leaves of the Dakota rocks." Dr. L. Lesquereux has discovered in the Kansas Dakota leaves a genus which he has named Betulites, and this genus shows the singular character of having a single stipule at the base of the petiole instead of a pair, furnishing thus a feature which allies our modern dicotyledons with those of the Cretaceous. In a lecture Prof. Hay reviewed the geology of Kansas. Mr. E. Jameson gives the geology of the Leavenworth deep well, which went down 2116 feet. It gave indications of petroleum and gas, but failed because of the impossibility of shutting off the voluminous flow of water. Prof. Hay describes the saliferous horizon of the Triassic, stating that these beds are continuous without break into the Permo-Carboniferous. Prof. Snow gives the result of an examination of the Logan county so-called nickel mines. This was noted in the AMERICAN GEOLOGIST, vol. III, p. 216. Profs. Blake and Bailey made a thorough examination of the evaporating power, composition and peculiarities of Kansas coals. It was found that they depreciate in their steam-producing powers, and in their content of fixed carbon, from the southeastern part of the state toward the north and west.

Application of descriptive geometry to a series of problems in locating faulted beds or veins. By E. H. WILLIAMS, JR. A brochure of 23 octavo pages, Bethlehem, Pa. These problems and their solution, embracing most of the irregularities with which miners have to contend, will be useful in mining schools where the methods of nature in concealing her coal, iron and other valuable beds, are reduced to geometric figures and mathematical formulæ and revealed to the student.

BIBLIOGRAPHY OF NORTH AMERICAN VERTEBRATE PALÆONTOLOGY FOR THE YEAR 1889. By John Eyerman, Easton. c indicates illustrations in the text; pl. plates.

1.	**Cannon jr. G. L.**	Brief remarks on horned Dinosauria. Proc. Colorado Scientific Society, Jan. 15, 1889.
2.	**Cannon jr. G. L.**	On the Tertiary Dinosauria found at Denver, Col. Proc. Col. Sci. Soc. Vol. 3, part I, p. 140.
a.	**Baur G.**.........	*Palæohatteria*, Credner and the Proganosauria Am. J. Sci. Vol. 37, p. 310.
3.	**Cope E. D.**......	An intermediate Pliocene fauna. Am. Nat. April, '89, p. 355 (253).
4.	**Cope E. D.**......	A Review of the North American species of Hippotherium, 29 p. 3 pl. Proc. Am. Phil. Soc. Vol. 26, 429.

5. **Cope E. D.**......	Cœlophysis, a new Triassic Dinosaurian genus. Am. Nat. July 1889, p. 626.
6. **Cope E. D.**......	Marsh on Cretaceous Mammals. Am. Nat. June 1889, p. 490.
7. **Cope E. D.**......	On a species of Plioplarchus from Oregon. Am. Nat. July, 1889, p. 625.
8. **Cope E. D.**......	On the North American Proboscidia. Proc. Nat. Acad. 1889.
9. **Cope E. D.**......	On the Vertebrata of the Miocene of the Cypress Hills of Canada. Proc. Nat. Acad. Nov. 1889.
10. **Cope E. D.**......	Pliocene Vertebrate Fauna of Western North America. Proc. Nat. Acad. 1889.
11. **Cope E. D.**......	The Artiodactyla. 36 p. 5 pl. Am. Nat. Feb. 1889, p. 211 (111).
12. **Cope E. D.**......	The Edentata of North America. 8 p. c. Ipl. Am. Nat. Aug. 1889, 657.
13. **Cope E. D.**......	The Proboscidia. 20 p. c. 8 pl. Am. Nat. April, 1889, p. 291 (191).
14. **Cope E. D.**......	The horned Dinosauria. 3 p. 2 pl. Am. Nat. Aug. 1889, p 715.
15. **Cope E. D.**......	Vertebrata of the Swift Current river, Am. Nat. March, 1889, p. 251 (151).
16. **Cope E. D.**......	Vertebrata of the Swift Current river, Am. Nat. July, 1889, p. 628.
17. **Cope E. D.**......	Vertebrate fauna of the Equus beds. 5 p. Am. Nat. Feb. 1889. p. 160.
b. **Cross Whitman.**	Denver Tertiary Formation. Am. J. Sci. vol. 37, p. 261.
c. **Eyerman John.**	Tracks of Brontozoum, Grallator and Anomœpus from New Jersey Triassic. Proc. Acad. Nat. Sci. 1889, p. 32.
18. **Leidy Joseph**...	Cave fossils (in Penn.) 20 p. 2 pl. Ann. Rept. Geol. Sur. of Penn. for 1887. Issued 1889.
19. **Leidy J.**........	Fossil Vertebrates from Florida. Proc. Acad. Nat. Sci. 1889, p. 96.
20. **Leidy J.**........	Sabre Tooth Tiger of Florida. Proc. Acad. Nat. Sci. 1889, p. 29.
21. **Marsh O. C.**....	Comparison of the principal forms of Dinosauria of Europe and America. 8 pl. Am. J. Sci. vol. 37. p. 324.
21. d **Marsh O. C.**....	Comparison of the principal forms of Dinosauria of Europe and America. Geological Magazine, vol. 6, p. 204.
22. **Marsh O. C.**.....	Discovery of Cretaceous Mammalia. 4 p. Am. J. Sci. vol. 38, p. 81.
23. **Marsh O. C.**.....	Discovery of Cretaceous Mammalia. II. Am. J. Sci. vol. 38, p. 177.
24. **Marsh O. C.**.....	Notice of Gigantic Horned Dinosauria of the Cretaceous. c. Am. J. Sci. vol. 38, p. 173.
25. **Marsh O. C.**.....	Notice of new American Dinosauria. c. Am. J. Sci. vol. 37, p. 331.

26. **Marsh O. C.**.....	Restoration of *Brontops robustus* from the Miocene of North America. 1 pl. Am. J. Sci. vol. 37, p 163.
26. e **Marsh O. C.**.....	Restoration of *Brontops robustus*, etc. 1 pl. Geol. Mag. vol. 6, p. 99.
27. **Marsh O. C.**......	The skull of a gigantic Ceratopsidæ. 1 pl. Am. J. Sci. vol. 38, p. 501.
28. **Matthew G. F.**..	On an Upper Silurian Fish. Trans. Roy. Soc. Canada, vol. 6.
29. **Newberry J.S.**..	Fossil Fishes (and Fossil Plants) of the Triassic Rocks of New Jersey and the Connecticut Valley. 95 p. 26 pl. U. S. Geo. Sur. Monograph 14, dated 1887, issued 1889.
(32.) **Osborn H. F.**	See Scott and Osborn, No. 32.
30. **Seeley H. G.**....	On the pelvis of Ornithopsis. (See the discussion.) Quart. J. Geol. Soc. XLV. p. 391.
31. **Scott W. B.**.....	Notes on the Osteology and systematic position of *Dinictis felina* (Leidy) c. 33 p. Proc. Acad. Nat. Sci. 1889. p. 211.
32. **Scott W. B.**..... and **Osborn H. F.**....	The Mammalia of the Uinta formation. Parts I, Geological and Faunal Relations, and II, The Creodontia, Rodentia, and Artiodactyla by W. B. Scott. Parts III, The Perissodactyla, and IV, The evolution of the Ungulate foot by H. F. Osborn. c. 5 pl. 112 p. Trans. Am. Phil. Soc. vol. 16. p. 461.
33. **Traquair R. H.**..	On the Devonian Fishes of Canada. Brit. Assn. Rept. 1889.
f. **Wanner A.**.....	Discovery of Fossil Tracks, etc., in the Triassic of York county, Penn. 11 p. 15 pl. Ann. Rept. Geol. Sur. of Penn. for 1887, issued 1889.
34. **Whiteaves J. F.**	Cretaceous Fossils from Manitoba. Cont. to Canadian Pal. vol. I, part II, p. 191.
35. **Whiteaves J. F.**	Devonian Fossil Fishes. Trans. Roy. Soc. of Canada, vol. 6.
36. **Whiteaves J. F.**	On Some Fossils from the Hamilton of Ontario. Description of *Macroptalichthys sullivanti*. Cont. to Can. Pal. vol. I, part II, p. 119.

List of new genera and species described in the above memoirs.

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I. minutus, Newb	29
I. modestus, Newb	29
Lamna manitobensis, Whiteaves	34
Leptomeryx esulcatus, Cope.	15
L. semicinctus, Cope	15
Menodus selwynianus, Cope.	16
M. syceras, Cope	15
Monoclonius fissus, Cope	14
M, recurvicornis, Cope	14
M. sphenocerus, Cope	14
Morosaurus lentus, Marsh	25
M. agilis, Marsh	25
Nanomys minutus, Marsh	22
Nodosaurus textilis, Marsh	24
Oracodon anceps, Marsh	23
Pediomys elegans, Marsh	22
Platacodon nanus, Marsh,	23
Plioplarchus septemspinosus Cope	7
Ptycholepsis marshii, Newb.	29
Ptychodus parvulus, Whiteaves	34
Selanacodon brevis, Marsh	23
S. fragilis, Marsh	22
Stagodon nitor, Marsh	23
Tetrabelodon brevidens, Cope	14
Triceratops flabellatum, Marsh	24
T. galeus, Marsh	24
T. horridus, Marsh	24
Tripriodon caperatus, Marsh.	22
T. cœlatus, Marsh	22

CORRESPONDENCE.

Additions and corrections to Miller's North American Palæontology. Nothing better illustrates the necessity recently urged by the writer in the *American Naturalist*, for some concerted action to secure the authoritative compilation of literature, especially the description of new species, than the manifest impossibility for any individual to be perfectly sure of complete success in attempting a synopsis of the described species known from any period. While, no doubt, honestly designed to secure completeness, the valuable work quoted above loses something of its authoritativeness because of sundry omissions. It is, therefore, suggested that the lack may be measurably supplied, for the present, if those who detect such omissions make it their business to supply the data to the public, for which purpose the Geologist might be a suitable avenue.

A list herewith communicated consists chiefly of species figured by C. L. Herrick in the several bulletins of Denison University from 1887 to 1889. For the sake of brevity these species are followed by simply a Roman and an Arabic numeral, the former indicating the volume, the latter the page. Vol. ii appeared in May, 1887, vol. iii in April, 1888, vol. iv in December, 1888.

Two other species may also be added as follows:

TRILOBITES.

Phillipsia sampsoni Vogdes. Waverly.
Trans. New York Academy of Sciences, vol. III, p. 246.

Griffithides? sedaliensis Vogdes, Waverly.
Trans. New York Academy of Sciences, vol. VII, p. 276.

Erase on p. 562, *Phillipsia longicaudata* Hall, as a synonym for P. sangamonensis, a Coal Measures species.

CRUSTACEA.

Phillipsia consors, Keokuk or Burlington. IV. 53.
præcursor, Kinderhook, III, 29.
serraticaudata, Keokuk, IV, 52.
shumardi, Kinderhook, II 69.=Petus or auriculatus Hall.
trinucleata, Coal Meas. II, 64.
Proetus minutus, Kinderhook, IV, 56.
Phaethonidæs immaturus, Kinderhook. IV, 59
occidentalis, Kinderhook, IV, 57.
spinosus, Kinderhook, 58.
Cythere ohioense? Keokuk, IV, 60.

BRACHIOPODA.

Athyris ashlandensis, Kinderhook, IV, 24.
Chonetes tumida, Kinderhook, III, 36.
Lingula atra, Waverly shales, IV, 16.
gannensis, Burlington? IV, 17.
mecki, Waverly shales, IV, 18.
tighti, Coal Meas. II, 43.
waverliensis, Burlington, IV, 18.
Orthis pulchella, Kinderhook, III, 38.
Productus annosus, Kinderhook, IV, 20.
raricostatus, Kinderhook, IV, 19.
rushvillensis, Burlington, IV, 22.
Rhinchospira? ashlandensis, Kinderhook, IV, 25.
Spirifer deltoides, Kinderhook, IV, 27.
S. (Martinia) tenuispinatus, Kinderhook, IV, 27.
winchelli, Kinderhook, III, 46.
Spiriferina depressa, Kinderhook, III, 47.
Stricklandi? subquadrata, Coal, Meas, II, 49.
Terebratula inconstans, Kinderhook, IV, 24.

GASTEROPODA.

Flemingia? stulta, Kinderhook, IV, 45.
Pleurotomaria strigulata, Kinderhook, III, 86.

PTEROPODA.

Conularia gracilis. Kinderhook. IV, 48.
Dentaluim granvillense, Kinderhook, III, 92.

HETEROPODA.

Bellerophon subcordiformis, Coal Meas. II, 18.

LAMELLIBRANCHIATA.

Allorisma convexa, Kinderhook, III, 74.
consanguinata, Burlington, IV, 29.
cooperi, Kinderhook, III, 72.
cuyahoga, Waverly shales, IV, 28.
Avicula recta, Waverly shales, IV, 115.
subspatulata, Burlington, IV, 30.
Aviculopecten cooperi, Kinderhook, III, 51.
granvillensis=A crenistriatus.
perelongatus, Kinderhook, III, 50.
scalaris, Coal Meas., II, 26.
sorer, Coal Meas., II, 27.
Crenipecten foerstii, Coal Meas., II, 28.
senilis, Kinderhook, III, 54.
subcordiformis, Kinderhook, III, 55.
Conocardium alternistriatum, Kinderhook, IV, 42.
Cypricardinia? scitula, Kinderhook, IV, 38.
Edmondia sulcifera, Kinderhook, IV, 30.
Entolium attenuatum, Coal Meas.. II, 24.
Gervillia? ohioensis, Coal Meas., II, 36.
Goniodon ohionsis, (= ? Palæaneilo) III, 84.
Grammysia famelica, Kinderhook, IV, 35.
ovata, Burlington, IV, 35.
Leiopteria halli, Kinderhook, III, 65.
nasuta, Kinderhook, IV, 29.

newberryi, Keokuk? Iv, 114.
ortoni, Kinderhook, iii, 60.
Leptodesma? scutella, Kinderhook, iii, 59.
Limatulina ohioensis, Burlington, iii, 55
Lyriopecten cancellatus, Kinderhook, iv, 54.
nodocostatus, Kinderhook, iv, 32.
Macrodon newarkensis, Burlington, iv, 36.
striatocostatus, Kinderhook, iv, 37.
(*Macrodon?? triangularis*,=Schizodus).
Modiola waverliensis, Kinderhook, iii, 63.
Nuculana similis, Kinderhook, iii, 79.
spatulata, Kinderhook, iii, 79.
Oracardia, Herrick, Bul. Denison Univ., vol. iv, p. 41. [Ety. *oraios*, beautiful; *Kardia*, heart]. *Dexiobia* Winchell, *pars*. Type O. ornata.

Shell somewhat inequilateral, more or less inequivalve, both valves ventricose with a strongly curved, acute, elevated beak, which inclines forward at the apex. Hinge line extended, produced posteriorly, furnished with a thickened ridge or cartilage-plate. The beaks separated from the hinge by a pseudo-area, which is elevated and more or less arched under the beak. Surface marked by radiating lines which do not increase toward the front.

ornata, Kinderhook, iv, 41.
cornuta, Kinderhook, iv, 42.
Palæarca ornata, Kinderhook, iii, 83.
Palæaneilo consimilis, Kinderhook, iv, 43.
curta, Kinderhook, iv, 44.
elliptica, Kinderhook, iii, 80.
ignota, Kinderhook, iv, 44.
Pleurophorus immaturus, Coal Meas., ii, 145.
Promacra? truncatus, Kinderhook, iii, 60.
Posidonomya fragilis,Kinderhook, iii, 59.
Pterinopecten? ashlandensis, Kinderhook, iv, 33.
carniferus, Kinderhook, iii, 58.
Pteronites obliquus, Kinderhook, iii, 58.
Sanguinolites senilis, Kinderhook, iii, 66.
Schizodus affinis Coal Meas., ii, 41.
harlamensis, Berea grit, iv, 117.
newarkensis, Burlington, iii, 64.
palæonciliformis, Kinderhook, iii, 96.
prolongatus, Kinderhook, iv, 36.
? spellmani, Coal Meas., iv, 42.
subcircularis, Coal Meas. iv, 41.
triangularis, Kinderhook, iii, 74; iv, 116.
Solenomya? cuyohognesis, Cuyahoga shale, iv, 115.
(?) *meekiana*, Coal Meas., ii, 30.
subradiata, Coal Meas., ii, 30.
Streblopteria gracilis, Kinderhook, iii, 57.
media, Kinderhook, iii, 56.
squama, Kinderhook, iii, 57.

C. L. Herrick.

Cincinnati University, February, 1890.

PERSONAL AND SCIENTIFIC NEWS.

Mr. John R. Procter, director of the Kentucky geological survey, is on an indefinite leave of absence, while doing some work in southwestern Virginia for ex-governor Lee and others, and meantime assistant M. H. Crump is in charge of the survey.

The American Naturalist, which has revived from its comatose condition, appears in good order and on time again. This admirable journal, more than twenty years old, now published by Ferris Bros., Philadelphia, contains the first announcements of many of the paleontological discoveries of Prof. E. D. Cope, and is well known in all scientific circles. It is with much satisfaction that we notice its establishment on a firmer basis, and we heartily commend it to all scientific students and libraries.

METAGADOLINITE—A NEW MINERAL. E. Goldsmith (Jour. Anal. Chem. vol. IV, page 23.) in an article on "Gadolinite from Llano county, Texas," describes and gives an analysis of this apparently new mineral, occurring as an incrustation upon the species gadolinite. As is so very frequently the case, incrustations are mixtures, Mr. Goldsmith resorted to several tests, which gave no evidence of a mixture, thereby proving it to be apparently a distinct species. The analysis gave,

SiO_2	18.145	YO	21.854
Ce_3O_4	20.662	CaO	3.642
Fe_2O_3	26.026	MgO	0.214
H_2O	9.761		

A hydrated tri-basic silicate represented by $2(RO+R_2O_4)SiO_2(\dot{R}O_{23})$. The mineral is amorphous, dull and brittle. Color: grayish brown. Streak: red. Hardness: 3. Sp. Gr. 3.494.

Within the past few months there have been described from the Llano Co. localities no less than four new and distinct species. Yttrialite, Thoro-gummite and Nivenite (Hidden and Mackintosh, Am. J. Sci. vol. 38, p. 473), and the above described species.

A GROUP OF METEORITES. Some "heavy stones" unearthed on a farm in Kiowa county, Kansas having been lying around for three years have recently been discovered to be meteorites. They have now all been distributed, some are gone to Washburn College, Topeka, others to the Kansas State University at Lawrence, the Minnesota State University and to Iowa. The largest is over 300 lbs weight and others vary down to about forty pounds. We will give a fuller account of these meteorites next month, but will say here that some of them are nearly all iron and others have nickel and cobalt, and also contain some earthly and glassy minerals.

A PATENT WATER-WITCH. According to the *Mining and Engineering Journal*, in which the details of the experiments are given, a Bavarian by the name of Heerdegen has an apparatus by which he detects the presence of water in subterranean reservoirs or streams, and which he will not yet fully describe nor allow to be inspected till he secures his patent. The instrument indicated, in the neighborhood of Sing Sing, the location of some of the new water-courses of the Croton aqueduct, the same being far below the surface and without any possible clue to their location, especially to a stranger. The old aqueduct in New York was in the same way accurately located by Mr. Heerdegen. Again 150 feet of ¾-inch steam hose was coiled about on the second floor of the Raub building, corner Nassau and Fulton sts. When subsequently filled with water, Mr. Heerdegen suceeeded fairly well in tracing on the next floor above the position and direction of the coil. Some other equally satisfactory tests were made.

1

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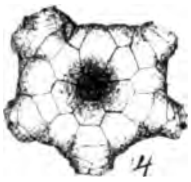

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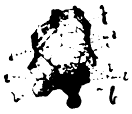

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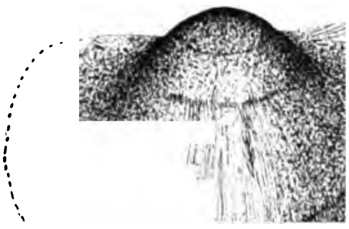

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OBSERVATIONS ON THE KEOKUK SPECIES OF AGARICOCRINUS.

By C. H. GORDON, Keokuk, Iowa.

[Read before the Iowa Academy of Science, Sept. 5, 1889.]

The Keokuk beds have thus far furnished six species referred to this genus, of which three—*A. Americanus* Rœmer, *A. whitfieldi* Hall, *A. wortheni* Hall—may be found in collections made at and about Keokuk. We have had access to a large number of these forms and from a somewhat careful study have become impressed with the need of a revision of this genus. As between *A. americanus* Rœmer, and *A. wortheni* Hall, the specific distinctness seems well established. The essential differences, as shown by Hall[1], occur in the second and third radials and in the interradial areas. In *A. wortheni* Hall, the *first interradials* are much shorter than in *A. americanus* Rœmer, thus bringing the *second interradials* much lower and giving them a proportionately greater prominence in the structure of the calyx. In consequence of this they are brought in contact with the *second radials* whose upper lateral angles are truncated to receive them, thus giving these plates, a hexagonal form, while in the typical form of *A. americanus* Rœmer the long *first interradial* and the quadrangular *second radials* are very characteristic. Moreover in the *A. wortheni*

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[1] Geol. Surv. Iowa., Vol. I, Pt. 2, p. 620.

Hall the third radial is a larger and stronger plate than is usually observed in the other, and the general form of this species is more robust. We have here, apparently, the culmination of this generic form which becomes extinct with the Keokuk period. One unusually large individual before us presents a remarkable development of the third primary radial. Four of these are extremely protuberant, the nodes projecting three-eighths of an inch from the surface of the calyx. The specimen measures an inch in hight by two and one-fourth inches in breadth. A tendency toward the same structure, (apparently due to age) has been noted in other specimens.

In *Agaricocrinus americanus* Rœmer we have a form presenting many variations of structure. Some of these have been mistaken for specific differences giving rise to the synonyms *A. bullatus* Hall. *A. excavatus* Hall. *A. nodosus* M. & W. *A. tuberosus* Troost. Among the specimens before us, usually referred to this species, are two forms which, as we believe, present more than varietal differences. While the distinctions giving rise to the above synonyms were largely superficial, in the present case the differences in structure seem to have a deeper significance. We shall attempt but a brief notice of them here.

In the typical form the basal concavity is said to involve the entire radial series of plates, while Messrs. Wachsmuth and Springer state:* "*The differences in the form of the calyx are modifications in geological succession. Species with convex sides are confined to the Waverly group and to the Burlington limestone: species from the Upper Burlington are truncate below, or slightly convex, rarely concave, while the Keokuk species without exception are deeply concave in the basal region.*"

We have a number of specimens in which the basal concavity is very shallow and does not involve the third radials and frequently only the basal plates. The third primary radials are more or less prominently convex, heavy plates as are also the interradials. In the postero-lateral rays one of the second radials is oblique and unequally quadrangular while the other (in the right ray) has its upper acute angle truncated by one of the interradial plates. In this particular it agress with *A. whitfieldi* Hall, from which it differs, however, in being much less concave below and more protuberant in the anal region.

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*Revision Palæocrinoidea. Part. II., p. 109.

All the examples noticed have regularly twelve arms and occur in the lower crinoid bed (No.2). If as stated by the above authors the modifications of the base denote geological succession we have here a continuation of the upper Burlington form with a slightly increased concavity. In this case it would seem proper to consider this form specifically distinct from the one to which it is now referred. On the other hand should these modifications be deemed varietal only, then no good reason would remain for retaining *A. whitifieldi* Hall, since that form is more nearly related to the typical *A. americanus* Rœmer than is the one under discussion.

An apparent exception to the rule given by Wachsmuth and Springer occurs in the case of *A. springeri* White, from Indiana, which is said to have the base truncate but not depressed. The type specimen was obtained from the "terrace drift, west bank of the Wabash, Clinton, Vermilion Co., Ind." Its geological horizon is therefore uncertain, and we are inclined to think it belongs to the upper Burlington.

Specimens of the subexcavate form may be seen in the collection of Mr. N. K. Bunket, Mr. L. A. Cox, and the writer.

In its normal state the *A. americanus* Rœmer is said to have twelve arms, three upon each of the posterior rays and two upon each of the others respectively. The number of arms is not constant however; additional arms frequently appearing upon the postero-lateral and antero-lateral rays. We have never observed more than two arms upon the anterior ray. In examining a number of specimens showing more than the normal number of arms we have been impressed with a certain uniformity of structure which it is difficult to believe to be merely accidental. Rarely or never do we find a division of one pair of rays only. The addition of arms on the postero-lateral rays is always accompanied, so far as we have observed, by an increase of arms in the antero-lateral rays. Of five examples before us, four have sixteen arms and one seventeen. Three have the arms regularly arranged—four on each postero-lateral ray and three on each of the antero-lateral rays. The other two are somewhat abnormal, one having two additional arms on one of the antero-lateral rays, making seventeen in all, while the other upon one side has both additional arms placed upon the antero-lateral ray. The tendency is clearly shown to be toward sixteen arms.

The basal concavity, which is exceptionally deep, involves the whole series of radials up to and partially including the secondary radial so that when placed base downward the fossil rests upon the somewhat protuberant secondary radials. In this feature it somewhat resembles *A. whitfieldi* Hall. Above the secondary radials the plates are much smaller than in the ordinary form. These examples all agree in the somewhat depressed structure of the dome and *very protuberant* anal region. The proximal and radial dome plates are quite prominently tumid with the exception of the third radial which is generally smaller than the others and somewhat depressed. The second radials are the largest and most tumid plates of the dome in rays having two arms, while the succeeding plates are obscure or absent; and in rays with more than two arms,two additional well developed plates occur. In rays having three arms, one of these plates is large and conspicuous while the other is small and crowded to one side; and in four-armed rays the two plates are equally prominent and placed side by side. The general form of the body is depressed wheel-shaped, and owing to the deeply excavate base the capacity of the internal cavity must have been very small.

In an examination as to the mode of origin of extra arms it was observed that, in those rays having normally three arms, the third arm arises from a single tertiary radial which truncates, usually, the upper and inner angles of the first secondary radials. In four-armed rays this plate is divided vertically thus forming two tertiary radials from each of which springs an arm. Sometimes the arms have the appearance of springing from the sides owing to being pressed outward by those within.

Nearly if not quite all the examples with sixteen arms from this locality are derived from the same geological horizon, viz.: the "Lower Crinoid Bed, (No. 2)" near the base of the lower division, and associated with the subexcavate form above noticed.

Keokuk, Iowa, March 8, 1890.

EXPLANATION OF PLATE

Fig. 1.—Agaricocrinus wortheni Hall.

Basal view of specimen showing deep concavity and hexagonal form of second radials.

Figs. 2, 3, 4.—Agaricocrinus americanus Rœmer.

Basal view of specimens having base but slightly depressed. Plates large and more or less prominent. Second radial in right postero-lateral ray truncated by interradial.

Fig. 5.—Agaricocrinus americanus Rœmer.

Specimens with sixteen arms and showing the very deeply excavate form of the base.

Fig. 6. Left postero-lateral ray of *A. wortheni* showing arrangement of plates:

a. First primary radial—hexagonal.
b. Second primary radial—hexagonal.
c. Third primary radial—pentagonal.
d. Secondary radials.
e. Interradial plates.
f. Arm plates.

The first secondary radial on the posterior side of the postero-lateral ray is essentially a brachial piece with two rows of additional plates upon its upper slanting sides.

Note.—The varying proportions of the first interradial in the above figures is especially noticeable. The anal area is directed upwards.

Fig. 7.—Orthis keokuk Hall. Vental valve.

The figures of this shell given by Hall were evidently from specimens more or less exfoliated. Well preserved specimens are rare. The above figure is from a specimen showing very prominent radiating striæ and concentric lines of growth. The striæ are fine and close up on the upper part of the shell but become abruptly coarser at each concentric line of growth. The plications are very prominent on the outer row.

Length 3 in. Transverse diameter 4½ in. Elevation at center 1⅛ in. Width of hinge line?

DRAINAGE SYSTEMS OF NEW MEXICO.[1]

By Ralph S. Tarr, Austin, Texas.

In the arid climate of New Mexico the annual rainfall in the highest mountains is often more than thirty inches; but over the larger part of the territory on all the plains and plateaus it is generally not more than twelve inches. During the summer months the country is liable to excessive rainfalls lasting for an hour or two and in that time doing great erosive work. Generally the erosion of a year is done in a few days. For the remainder of the year rains are rare and slight in amount and the water that falls sinks readily into the parched soil without doing any appreciable work of erosion. For nine months of the year the wind erodes more rapidly than the rain water.

New Mexico, being located within the area of the Rocky mountain uplift is topographically typical of that region. In the southeastern portion are the elevated prairie lands of the Llano Estacado,changing in the northwest to the true plateau, from which platform rise the mountains of the territory ranges, chains and isolated peaks. The mountain topography is not so striking in this territory as it is in the more northern portions of the Rocky mountain area; but in northern New Mexico are the lofty Taos and other ranges, spurs of the great Colorado system. The trend of all these ranges, with a few unimportant exceptions, is generally north and south. The valleys between the mountain ranges are broad, shallow plateau valleys, out of which the peaks and ranges appear to rise abruptly.

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[1] In the preparation of this paper I am indebted to Prof. Wm. M. Davis for valuable criticism and suggestions.

The rain that falls upon New Mexico finds its way into two oceans by means of three large arteries. The Continental Divide in the western portion sheds water into the Colorado on the west and the Rio Grande on the east. The Taos mountains near the Colorado state line form the divide between some of the head waters of the Rio Grande and the Canadian, one of the tributaries to the Arkansas. The Pecos, the chief branch of the Rio Grande also rises on the eastern slope of the Taos range and is separated from the Canadian by a low plateau divide. Nine-tenths of New Mexico lies within the drainage area of the Rio Grande or its tributary the Pecos; and the other two systems deserve mention simply in consideration of the drainage of this territory.

The history of these rivers has been interesting and complicated, yet the complication has not been such as to obscure the general changes that have taken place. A detailed history would demand a much closer study than I have been able to give and I shall not attempt to do more than state some of the most striking changes that they have undergone in the course of their development.

Many of the American rivers have existed as drainage systems through long geological ages and are by this time topographically as well as geologically old. The Rio Grande is both topographically and geologically young, and the appearance of youth is increased by certain accidents which have rejuvenated it. Moreover there are two sections of the Rio Grande and of each of its tributaries, one of which is much older than the other. It is plainly evident that the valleys of erosion in the mountains are much older than those on the plains even in places where the latter show no signs of rejuvenation. The mountain streams flow through broad valleys of construction and narrow gorges of erosion with rapid slope very much as in the case of any Rocky mountain stream. The difficulties in the way of erosion in such places are great, yet they have been overcome and well established valleys have been cut. Undoubtedly the mountain erosion has been in progress with slight interruption since the mountains first appeared as such.

After emerging from the mountains the Rio Grande flows upon a plateau, lava-capped in places, and almost everywhere composed of loose, partially consolidated, Tertiary fresh water deposits of cross-bedded sands and conglomerates. In the northern portion the river cuts a deep cañon through the lava and underlying sands; but this cañon character ceases to the south, and near the Texas line has entirely disappeared. Here the river flows near the top of the plateau in a broad valley a hundred feet or less below the level of the plateau.

The Rio Grande flows directly southward from Colorado to Texas in a broad valley of construction between the broken ranges of mountains, and its tributaries have for their divides mountain ranges; but in no case that I know do they cut across them. This is very different from what is generally noticed in mountainous regions. In Montana, for instance, almost all the large rivers cut directly across mountain ranges in actual erosion valleys. This is the case in the Madison, Jefferson, Gallatin, Missouri, Clark's Fork of the Columbia, and others. I am inclined to take this as evidence that at the time the mountains in New Mexico commenced to be crumpled the territory was beneath the ocean and that the great plateau regions were not raised above sea level until the mountain folds had assumed their present form, although probably not their present elevation. The fact that the mountain erosion is relatively so much further advanced than the plateau erosion seems to point to the same conclusion.

In the whole course of the Rio Grande from the northern to the southern boundary of New Mexico the river valley is for the most part carved out of soft unconsolidated sands and conglomerates. Nearly all of these deposits are old lake or inland sea beds of late Tertiary age. My studies have not been made in sufficient detail to tell whether the sands were deposited in one great lake or in numerous small ones. There are some indications that the former is the case. Be this as it may, the fact remains that the drainage from the mountains was into water in the near neighborhood either in the form of small lakes or large bodies. When these lakes were partially filled and their barriers removed, as was the case I think at El Paso, where the Rio Grande has cut a gorge across a mountain chain, a system of drainage began to establish itself in the old lake bottoms. At this time the mountain drainage was well established while the plateau drainage was only begun.

How far this plateau erosion had proceeded when the great New Mexican basalt period of late Tertiary times began it is difficult to say; but there are indications that the drainage was in a state of extreme youth. In several places beneath the lava I have found signs of sharp erosion such as is characteristic of young drainage. This is particularly well shown below Santa Fé on the Santa Fé creek, which in cutting the lava has revealed a narrow cañon sloping to the south and now filled with lava. This Tertiary river channel not only shows on both sides of the Santa Fé creek; but also several miles north of this point at a place plainly visible from the Texas, Santa Fé and Northern Railway. At this place, which is near the base of the mountains, there was considerable erosion before the flow of basalt began; but further north, between Embudo and Baranca the early drainage was not marked and the Tertiary sands beneath the lava are flat topped, level and only slightly disturbed by erosion.

Where this basalt flowed from has, I believe, been a disputed point. Some hold that it may have flowed from great cracks in the earth, others from cones. Of the former theory there are no proofs in this section; but, on the contrary there are many cones from which vast flows of lava poured forth. At "Volcano," near the Colorado line, on the Denver and Rio Grande Railway, is one of these old volcanic cones. On each side of the cone there is a great thickness of basalt: but the lava thins out on all sides and at Embudo, 60 miles south from the cone, it has a thickness of only twenty to thirty feet. Fifteen miles below Embudo the lava exists on the surface only in the form of boulders. The basalt that flowed from this cone alone covers an area of 2000 miles that can be traced. There are numerous other cones in northern New Mexico from which similar large quantities of basalt flowed. There is very little doubt that most if not all the Tertiary basalt in this section can be directly traced to some volcanic cone.

When the basalt flowed from the various cones it formed dams at many places across the developing rivers. One of the principal of these dams was at the eastern base of the "Volcano" cone and thence southward for 60 miles. The effect of this dam was to make a large lake having an area of several hundred square miles, since drained, and now called the San Luis Park in southern Colorado. This rejuvenation of the young Rio Grande system took place at many points and numerous small lakes were formed principally at the mouths of west-flowing tributaries. One of these may be seen at the town of Embudo near the mouth of the Embudo river. These lake deposits can be distinguished from the earlier Tertiary sands by the great abundance of basaltic pebbles in the former. In some places the upper layers of the great Tertiary conglomerate contain occasional basalt pebbles showing that the Tertiary lava period began before the final drainage of some of the lakes.

During the deposition of this lava the entire country was undoubtedly uplifted and when it ceased a new drainage system had to be established and a great work of rapid erosion to be begun, although the time has been short, the amount of erosion since the end of the basalt period has been very great. The rejuvenated Rio Grande has in every place succeeded in cutting through the lava cap and in many places has eroded far into the soft underlying deposits. From the southern end of the San Luis Park to below Embudo there is a great cañon averaging over a thousand feet in depth with a length of more than 60 miles and a width ranging from two thousand feet to two miles. The lava capping in the northern part being very thick, the underlying unconsolidated strata are protected and the cañon character of the river valley is well preserved. At the southern end, however, near Embudo, where the lava is only about twenty feet thick the cañon is broadening and rapidly loosing its distinctive steep-walled character. The wearing back of the basalt by subaërial denudation has broadened the cañon to a width of two miles. The soft clays and sands thus left exposed are rapidly melting away and are strewn with thousands of basalt boulders. Some of the hills are still lava-capped although they have sunk down several hundred

feet below their original level. This process of melting away of the clay beneath the lava is well shown along the basalt front where the lava has faulted off in long blocks in front of and below one another in a series of steps, which, at first sight seem to indicate a series of distinct flows.

In this vicinity there are many places where the surface is not strewn with basalt boulders although on nearly every side the boulders or basalt capping is found. At present such places are valleys but they undoubtedly represent the hills of the time when the basalt flowed over this country. This is very strikingly shown on the east side of the Rio Grande opposite the railway station of Embudo. At this point there is a high cañon wall of lava-capped sand, but just behind this, at a distance of only a few miles, there is a broad and rather deep valley. At the time when the lava reached this point sixty miles south of the cone the present valley was undoubtedly high land which the lava was unable to cover, and hence unprotected by lava it has readily fallen to a lower level than the neighboring valley of early times.

The Rio Grande on account of this rejuvenation is a superimposed river. To what extent its present course coincides with the course of early youth is difficult to say; but, in the northern portion, which I have studied particularly, I am inclined to believe that the rejuvenated course and the ancient course are practically the same. It is probable that in general the basalt flows coincided in direction with the principal valleys of the time. The greatest linear extension of the great flows from the "Volcano" cone were southward. At Embudo 60 miles from the cone, there are evidences at present of several distinct flows. At this point the flows were narrow and thin and now they cover the high land while both to the east and west there are deep valleys in the sand which has never been lava-capped. It seems therefore that the present southward extension of the lava points to the existence during the basalt period, of a river valley flowing southward through Embudo. The Rio Grande of to-day flows along this same course. Like all superimposed rivers it has been rendered liable by superimposition to certain accidents which present unnatural barriers for it to overcome. About ten miles above Embudo, for instance, the Rio Grande has, in cutting through the lava and sands, found in its course a buried hill of quartzite and schist:

and it is at present engaged in cutting through this barrier. From the structural features of the outcrop I infer that to the west about a mile the Rio Grande would not have encountered this rock, at least not for several hundred feet. Other similiar accidents are to be found at various places in the course of the river. I believe that a careful study of the river west of Santa Fé will show that it has been turned many miles to the east of its early course by a great thickness of lava; but I was unable to spend the time necessary for the verification of this supposition.

It is evident that the development of the cañon of the Rio Grande was rapid, first because it is only slightly effected by subaërial denudation; and, secondly from the evidences furnished by the side streams. The greater part of the work in the formation of the Rio Grande cañon was the removal of the very uppermost layers which were hard basalt. After this was cut through the remaining work was, with some local exception, the removal of the soft deposits which could be cut away as fast as the stream could dispose of the load. Hence the first hundred feet of cutting was slowly done and the next nine hundred feet of rock was quickly removed. While the river was busy cutting through the lava the side streams had very little opportunity to cut channels since they were retarded in their work of erosion by the main stream to which they were tributary. When once the Rio Grande succeeded in eroding through the lava crust and began to eat rapidly down through the sands, the tributaries began to cut into the lava, first near their mouths then progressively up stream farther and farther. Erosion at the mouths of these tributaries very nearly kept pace with the deepening of the Rio Grande itself; but from this point upstream for a few miles the slope is very rapid until the lava-capping is reached where the stream is laboring hard to get through the rock into the soft sands below and gain upon the stream near the mouth.

This condition is excellently shown on the Rio Grande at the mouth of Taos creek. For a few miles from its mouth the creek is deep and cañon-like and at its mouth is as deep as the Rio Grande itself, which, at this point, is at least a thousand feet below the plateau surface. The cañon grows progressively shallower upstream, and a little more than five miles from its mouth the stream is on the lava; and one or two miles upstream from this it has cut into the lava only five or ten feet. The side streams tributary to Taõs creek exhibit the same phenomenon on a smaller scale. This shows with what rapidity the erosion goes on after the lava is cut through and how young the drainage really is. In these creeks we see on a small scale what the Rio Grande has been doing on a large scale since the basalt flow first interruped its course.

The youth of the present Rio Grande drainage system is equally well shown in regions not covered with lava. Such places are also rejuvenated, in the north at least, by the lava flows, which, by impeding the Rio Grande itself also impeded all the side streams. At present these places are only just recovering from the accident. If the region was a moist one there would be no such signs of present recovery as can be seen there. As it is, in this case the rainfall peculiarities aid in the appearances of extreme youth. Aside from the main streams having sources in the mountains, there are few which carry water all the year, and not a great many well established tributaries to carry off the excessive floods to which the country is sometimes subject. Consequently every heavy rain develops new branches to the smaller tributaries. These "arroyas," as they are called, develop suddenly, even in a single storm, and often have a linear extension of several miles and a depth of fifteen to twenty-five feet with cañon-like walls of gravel. Other arroyas are growing slowly year by year at their headwaters. Very frequently an arroya eats back across a well traveled road, sometimes suddenly in a single storm; but very often slowly year by year so that each year the road is moved to make a detour greater and greater in extent until in some cases the angle of the road at the head of an arroya is as much as a quarter of a mile from its former position a few years previous.

When a small arroya is formed many tons of earth are removed and carried into the main stream as a burden to be carried to the sea. While the Rio Grande was cutting its own cañon it was able to handle the burdens, partly because it was not particularly overburdened and partly because its slope seaward was rapid. Now the slope is reduced while the river is overcoming dams at various places (as at El Paso), and the main stream is burdened with sediment furnished by all its tributaries which are busily at work establishing themselves. Such streams as the Chama and Puerco always have as much sediment in their grasp as can be carried. This overburdening of the river has brought about a new condition of things with which the steam is now complicated. The river unable to carry off all the sediment furnished to it, is laying it aside in sand bars and flood plains until such time as the equilibrium shall be restored. This clogging increases to the south; and, at Las Cruces, in southern New Mexico just north of the reef of rock at El Paso with which the Rio Grande is contending, the river winds in and out among bars of quicksand and broad flood plains which are being added to each year. In this valley, the Mesilla valley, the river flows with an uncertain course and frequently changes its channel.

The Rio Pecos is at present in about the same condition as the Rio Grande. It is building up its channel with the silt with which it is over burdened. This river is also in its youth, and, I believe, a rejuvenated youth. In its upper portion it flows in a cañon-like valley of recent date very likely due to rejuvenation resulting from the plateau uplift. The condition of youth is well proved by the fact that great areas on the border of the Staked Plains are entirely destitute of drainage. Arroyas are everywhere forming and many roads on hillsides have been abandoned because during a rain they have been transformed to arroyas. Much of the drainage is underground, and these subteranean creeks appear in or near the Pecos as great springs flowing many cubic feet of water per second, as at Roswell.

Between the Pecos and Rio Grande there is a great area of country having no surface drainage seaward. I refer to the area lying between the Organ and San Andreas range on the west, the White Mts. and small outliers on the north, the Sacramento and Guadolupe Mts. on the east and the Hueco and El Paso mountains on the south. Between these mountains is a great basin which for the want of a better name I shall call the Gypsum Plains. The length of this basin is 125 miles or more and the width varies from 10 to 30 miles. From Sierra Blanca which attains an elevation of 11892 feet and is snow-capped the greater part of the year, and from other portions of the White Mountain range there are several brooks of good size flowing into the enclosed basin. The principal ones are Tula Rosa creek, Bonito creek and Three Rivers. Each of

, after emerging from the mountains, quickly d c loose gravels of the basin, probably the depos of Tertiary lake bed. From each of the other ranges r streams and arroyas empty into the basin but the disappears shortly after reaching the plain.

Near the western margin of the plain at the base of San ndreas range is an extensive salt marsh; and just to the outh of this are the so-called white sands—a large deposit of gypsum. I am convinced that this is the last remnant of what was once a large lake now destroyed by desiccation. At present there is no surface drainage out of the basin and a very little brackish water collects in the lowest part of the old lake bed. It is completely isolated from the great drainage area of the territory and receives the rainfall of an area fully 4000 square miles in extent.

Conclusion. Condensing the above in a few words, I consider the history of the New Mexican drainage systems to first commence when the southern spurs of the Rocky mountains appeared above the sea. During their slow uplifting well established streams carved the existing mountain valleys flowing first into the sea and later into large bodies of fresh water. Grand subsequent uplifting has not appreciably affected the torrential mountain stream valleys. By the removal of barriers and probably in some cases by desiccation the lake beds became dry land and a young drainage began to establish itself. At this time the plateau uplift began and with it came the vast flows of basalt deluging the greater part of the lowlands of the territory. When this fiery deluge ceased the rejuvenated Rio Grande began anew, settling in many places in its ancient valley but in others encountering unexpected barriers. The river, then rejuvenated and superimposed has since been employed in cutting a deep cañon. This stage has now ceased, the cañon is beginning to lose its distinctive character, the side streams are repeating the example of the mother stream and burdening it with an impossible load, which, being unable to carry, it is lying aside for some future time of leisure or power.

NEW LAMELLIBRANCHIATA.

By E. O. Ulrich, Newport, Ky.

No. 1, Containing Descriptions of new species of Modiolopsis.

This is the first of a series of papers on this class of foss shells that I propose to publish during this year, probably monthly in succeeding numbers of the Geologist. Most of the species were studied in 1880 and 1881 with a view of publishing descriptions of them, together with new Gastropoda and other fossils, in the ill-fated vol. III of the Ohio palæontological reports. As is well known, the Ohio Legislature has persistently refused to appropriate the funds necessary for the publication of that volume, and, as far as can be ascertained, the prospect at present is more discouraging than ever before. That the work might not be lost entirely, I have lately begun making a new set of drawings (this time in ink, making cheap reproduction possible) of the principal species then worked on, and of the more interesting forms that have been discovered since.

The total number of species which I propose to describe in this series of papers is over fifty, and of all of them the types are contained in my private collection. Among them are representatives of five or six new genera, while the remainder are referred to *Modiolopsis*, *Orthodesma*, *Cuneamya*, *Grammysia*, *Goniophora*, (?) *Ambonychia* and *Pterinea*.

Though a large number it is scarcely one-third of the undescribed Silurian lamillibranchs known to me—and many more no doubt still remain to reward the search of earnest collectors. To give some idea of the great variety of this class of fossils in Lower Silurian deposits, I will mention a few facts regarding those found in the Trenton and Cincinnati rocks of Ohio, Indiana and Kentucky. My own cabinet alone contains over two hundred unquestionably distinct species of lamellibranch shells from this locality. Of this number not more than eighty can be identified with described species, thus leaving over one hundred and twenty-eight without names, and I have not all of them either, since every extensive Cincinnati collection examined by me contains a greater or less number of species not represented in mine. A fair estimate of the total number from this locality alone would not fall below two hunand fifty species. And yet it is with this class of shells as with nearly all other fossils outside of the Echinodermata and Trilobita—they are sadly neglected by the average collector. Why this is so I do not know, since they are just as valuable to the science of geology and quite as interesting as crinoids and trilobites. It is to be hoped that hereafter collectors, particularly those in Lower Silurian localities of the west and northwest, will pay more attention to these fossils so that a monographical study may soon become practicable.

Modiolopsis oblonga, n. sp.

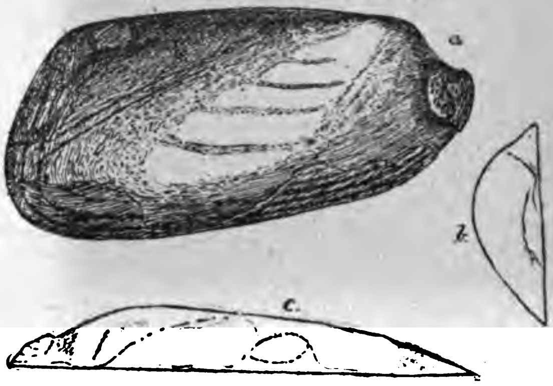

Fig. 1. *Modiolopsis oblonga*, n. sp., Utica slate horizon of the Cinnati group, at Covington, Ky. *a.* A very perfect cast of the interior of a right valve of this species, preserving a little of the shell, and exhibiting most of the distinctive features of the species. *b* and *c.* End and cardinal views of same to show convexity.

Shells above the medium size, moderately convex, elongate, the length more than twice the width, the posterior end a little the widest, anterior end small, contracted in front of the beaks, the upper portion slightly concave, the lower part narrowly rounded. Basal margin slightly convex or nearly straight, in the central half, and gently curved upwards at the ends. Posterior margin obliquely subtruncate, with point of greatest extension in the lower half where the curve is sharp. Junction of cardinal and posterior margins subangular, the two sides meeting at an angle of 120°. Cardinal margin very gently arcuate, long, the length behind the beaks equaling nearly three-fourths of the entire length of shell. Beaks small, depressed, scarcely elevated above the hinge line; situated one-eight of the greatest length of the shell from the anterior extremity. Umbonal ridge subangular near the beaks, but becoming nearly or quite obsolete before reaching the middle of the valve. Cardinal surface flattened. General surface of valves moderately convex, with greatest convexity in the anterior third.

Casts of the interior show an undefined flattening or very shallow depression in the region included between the anterior muscle, the basal margin and the umbonal ridge. Anterior muscular impression large, deep, subcircular, and roughly pitted. Posterior scar large, faintly impressed, situated near the center of the cardinal slope. Shell rather thick, (for this genus) and marked with fine impressed concentric striæ, invisible to the unaided eye, and stronger lines of growth.

Length 62.5 mm.; greatest hight (measuring across the posterior third of shell) 29.5 mm.; hight from beaks to ventral margin 21 mm.; greatest convexity of single valve (the point is near the middle of the anterior half) 8.5 mm.

From *M. modiolaris* Conrad, this species differs in its more elongate form, more nearly parallel basal and cardinal margins, convex or straight, instead of sinuate basal margin, greater prominence of umbones, and in being most convex in the anterior half of the shell, instead of the posterior. *M. cincinnatiensis* H. and W., with which it is associated, differs in its outline and surface markings, as well as in being more convex. *M. subparallela*, of this paper, agrees very well, as far as the mere outline is concerned, but it is a much smaller species, with the point of greatest convexity near the center of the shell instead of in the anterior half. *M. pholadiformis* Hall, likewise agrees very well with this shell, but the peculiar divaricating plications which mark the surface of that species are so distinctive that there is little danger of confounding the two species.

Position and locality: Utica slate horizon of the Cincinnati group, at the Covington, Ky., "river quarries," where it was found associated with *M. cincinnatiensis* and a number of other fossils that are restricted to that horizon.

Modiolopsis subparallela, n. sp.

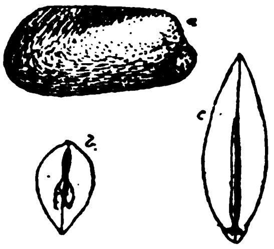

Fig. 2. *Modiolopsis subparallela*, n. sp. Cincinnati group, Coving-

ton, Ky. *a*, *b* and *c* three views of the best specimen seen. It is a cast of the interior and the largest seen.

Shells below the medium size, rather convex, elongate, the length equalling more than twice the greatest hight. Cardinal and basal margins nearly straight, subparallel, diverging very slightly toward the posterior extremity. Anterior end very short, contracted in front of the beaks, narrowly rounded. Posterior end not evenly rounded, the curves being a little the shortest in the basal half. Beaks small; umbonal ridge scarcely defined, the whole surface of the valves being nearly evenly convex, with the point of greatest convexity a little in front of the center. The cardinal slope may be somewhat flattened.

Only casts of the interior have been observed. These indicate that the shell was marked with faint concentric lines of growth. The anterior muscular impression is unusually large.

Length, 25 mm.; length from beaks to posterior extremity of hinge line, 17 mm.; hight from umbones to basal margin, 10 mm.; hight from posterior end of hinge line to basal margin, 11.5 mm.; greatest convexity of entire cast, 8 mm.

This species resembles *M. anodontoides* Conrad, but differs somewhat in outline and in wanting a distinct umbonal ridge. Conrad's species evidently belongs to the same section of the genus as *M.cincinnatiensis* H.and W.,in which the shell is very thin and the anterior muscular impression faint.

Position and locality: The types are from the Cincinnati group at the hill quarries west of Covington, Ky., and north of Cincinnati, Ohio. The horizon is from 300 to 350 ft. above low water mark in the Ohio river. I have casts also of the same or of a similar species from an horizon about 200 ft. lower in the series.

Modiolopsis milleri, n. sp.

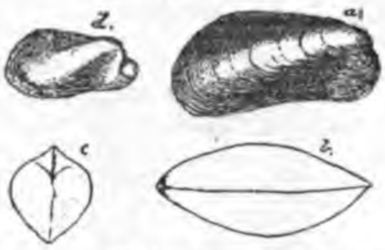

Fig. 3. *Modiolopsis milleri*, n. sp., Cincinnati group, Cincinnati, Ohio. *a*, a large specimen preserving the shell. *b* and *c*, cardinal and

end views of same. *d*, cast of the interior of the average size, showing the anterior muscle scar and deep impression just behind it.

Shell small, tranversely elongate subovate, the length a little more than twice the hight. Valves strongly convex, with point of greatest convexity near the middle, the surface sloping rapidly from there to the anterior and posterior extremities. Cardinal and basal margins subparallel, diverging very slightly posteriorly, the former very gently arcuate, the latter broadly sinuate. Anterior end very short, contracted beneath the beaks, and narrowly rounded. Posterior margin oblique, the basal half the most prominent and strongly curved. Beaks small, nearly terminal, umbonal ridge obtuse, but generally well developed, defined on the upper side by the flat or slightly concave cardinal slope, and on the other by the depression of the valves, causing the sinuate basal margin which is such a characteristic feature of the typical species of the genus. The sinus and depression are comparatively stronger in this specie than usual. Surface of shell with very fine concentric striæ and a limited number of stronger sub-lamellose lines of growth. Anterior muscular impression not deep, but bordered on the inner side by a strong clavicular ridge situated just in front of and below the beaks.

Length of a large specimen, 27 mm.; greatest hight (in the posterior half) 13 mm.; hight at beaks, 10 mm.; greatest convexity of both valves, 11 mm. In a small specimen these measurements are respectively, 14, 6.3, 5, and 4.5 mm.

This species is related to *M. modiolaris* Conrad, but is readily distinguished by its smaller size, comparatively greater convexity, stronger umbonal ridge, and more pronounced mesial depression beneath it. The two species differ also somewhat in their outlines.

The specific name is given in honor of Mr. S. A. Miller, who is one of the few palæontologists that have taken pains to collect and study the Cincinnati lamellibranchs.

Position and locality: Cincinnati group, on the hills about Cincinnati, Ohio, from about 300 to 400 feet above low water in the river.

Modiolopsis oviformis, n. sp.

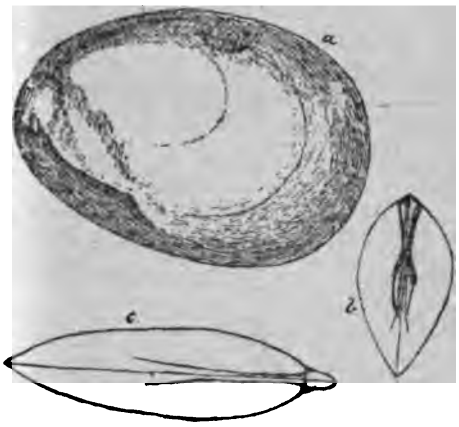

Fig. 4. *Modiolopsis oviformis*, n. sp. Middle Trenton, near Burgin, Ky. *a*, perfect cast of the interior of a left valve of this species. *b* and *c*, anterior end and cardinal views of a free cast of the interior, narrower than usual.

Shell of medium size, regularly oval transversely, the posterior half a little the widest, with the greatest hight and length, averaging respectively as three or three and one-half is to five. Valves moderately and nearly evenly convex, with point of greatest convexity a little in front and above the center. Cardinal margin strongly arcuate; basal margin with nearly the same amount of convexity; anterior and posterior ends nicely rounded, but with the former much narrower than the latter. Occasionally the posterior margin is produced slightly beyond an even curve in the postero-basal region. Beaks small, nearly terminal; umbonal ridge nearly obsolete. Shell rather thick, strongest in the umbonal region, its outer surface nearly smooth, exhibiting only a few faintly impressed fine concentric lines.

Casts of the interior, in which condition the species is usuually found, are terminated anteriorly by the well marked pair of muscular scars. The umbonal ridge is more pronounced than on the outside of the shell being defined anteriorly by a distinct depression. Good casts show a well defined impression of the characteristic Modiolopsis cardinal fold or tooth between the beaks and the anterior muscle scars.

A cast of a shell of the average size is 45 mm. long, 30 mm.

high and 13 mm. thick. The hight is proportionately somewhat greater in specimens preserving the shell.

This species has been confounded with *M. modiolaris* Conrad, by the Kentucky geologists. It is, however, quite a different species, being proportionally shorter, with a more arcuate cardinal margin, shorter and wider hinge plate, more nearly terminal beaks, and a different outline, the basal margin in Conrad's species being always more or less sinuate whereas it is convex in *M. oviformis*. Other differences might be mentioned, but these will suffice.

Position and locality: This species is very abundant in the argillaceous strata overlying the lower massive limestones of the Trenton of central Kentucky, at Burgin, Danville and Frankfort, Ky.

Modiolopsis simulatrix, n. sp.

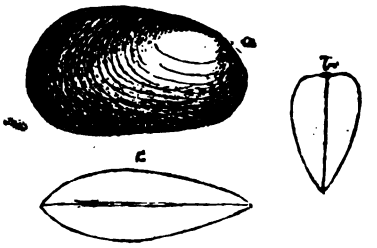

Fig. 5, ***Modiolopsis simulatrix***, n. sp., Cincinnati group (lower beds) at Covington, Ky. *a*, *b* and *c*, three views of a specimen of this species which preserves the shell. The postero-cardinal region should be a little more angular than shown.

Shell a little below the medium size, transversely subovate in outline, widest posteriorly. Valves moderately convex, with point of greatest convexity somewhat above and in front of the middle. Anterior end short,not appreciably contracted, rounding almost regularly from the beaks into the nearly straight or slightly convex basal margin. Posterior margin the most prominent at a point a little below the center,but not greatly so, the curve on the whole being nearly equal from the basal margin to the posterior extremity of the slightly arcuate hinge line, where the outline is often subangular. Beaks small not projecting above the hinge line, situated about one-sixth of the length of the shell from the anterior extremity. Umbones rounded. Surface between the umbones and the basal margin transversely flattened, but not sinuate; cardinal slope flat or slightly concave. Entire surface marked with two sets of concentric striæ, one set very fine and crowded, the other much coarser.

Length, 29 mm.; greatest width, (measuring from the posterior extremity of hinge to the basal margin) 17.5 mm.; width at the beaks, 12 mm.; greatest convexity of the two valves 9 mm.

This species should be compared with *M. modiolaris* Conrad, *M. concentrica* H. and W., and *M. subtruncata* of this paper. From the first it differs in having the basal margin convex instead of sinuate, the anterior end not lobate, a somewhat different outline, and in being both smaller and comparatively more ventricose. Similar differences distinguish it from the second, and to them may be added that in that species the concentric furrows are mainly restricted to the cardinal and posterior regions of the shell. In *M. subtruncata* the basal margin is straighter, the posterior end more obliquely truncate and the beaks more prominent. The surface is also without the strong concentric furrows and the outline generally different.

Position and locality: Rare in the lower beds of the Cincinnati group, at Covington, Ky., at an elevation of between 100 and 150 ft. above the Ohio river bed.

Modiolopsis pulchella, n. sp.

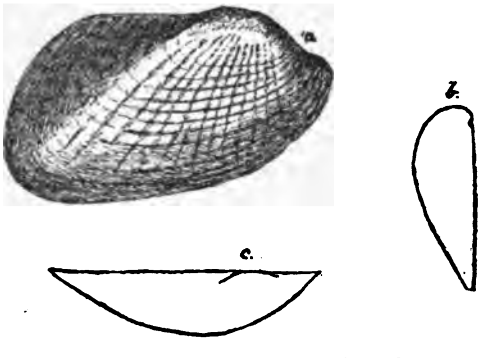

Fig. 6. *Modiolopsis pulchella*, n. sp., Utica slate horizon of the Cincinnati group at Covington, Ky. *a.* view of the only specimen seen. *b* and *c.* end and cardinal profile views to show convexity.

Shell of medium size, moderately convex, transversely subovate widest posteriorly, the greatest height and length, respectively, as five is to nine. Cardinal margin straight behind the beaks, bending down somewhat in front of them. Anterior end narrow, rather long, equalling one-fifth of the entire length of the shell; beginning at the junction with the hinge line the curve is sharp, then gentle as it merges into the convex basal line. Posterior end somewhat obliquely truncate; yet curving gently and uniformly from the narrowly rounded and prolonged postero-basal region into the cardinal margin. Umbones full, the obtusely angular umbonal ridge extending nearly to the postero-basal margin. Central portion of valves transversely flattened. Cardinal slope concave. Point of greatest convexity of shell above the center. Surface with concentric furrows and fine concentric lines. These are crossed by obscure broad radiating lines which probably indicate former color bands. Both the concentric and radial ornamentation is best developed in the central portion of the valves.

The shell was very thin, and the anterior muscular impression faint. Specimens of this species preserving the shell are not likely to be comfounded with any other species known to me. Casts of the interior in which the peculiar surface ornamentation would be absent, would not be so readily distinguished from similar casts of several species occuring in the Cincinnati rocks. There is however an appreciable difference in the outline and in none of these shells, is the umbonal ridge so well-marked a feature as in *M. pulchella*.

Position and locality. Rare in the Utica slate horizon of the Cincinnati group, at the "river quarries" a little west of Covington, Ky.

Modiolopsis subtruncata, n. sp.

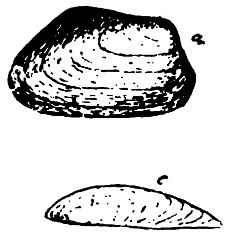

Fig. 7. *Modiolopsis subtruncata*, n. sp. Cincinnati group, Cincinnati, Ohio. *a*. right valve of this species, preserving the shell. *b* and *c* end and cardinal views of same to show convexity.

Shell of medium size or smaller, short, a little widest posteriorly, the greatest length and width, respectively, as nine is to six. Valves rather strongly convex, most prominent near the center, where the convexity of one valve equals about one-third of the greatest width. Cardinal margin straight, its length behind the beaks equal to a little more than half of the entire length of shell. Upper half of anterior margin straight or faintly concave, forming an angle of about 125° with the hinge line. Lower half curving rapidly into the straight basal margin, its curve equal to that of the margin in the postero-basal region. Upper half of posterior end straight, oblique, forming an angle of 130° with the hinge line; junction between the two, obtusely angular. Beaks small, slightly prominent, situated one-seventh of the entire length of shell from the anterior extremity. Umbonal ridge broadly rounded, not a conspicuous feature. Cardinal slope flattened. Surface with rather strong irregular lines of growth and a few finer concentric striæ.

Hinge plate narrow, with a long slender posterior tooth. Muscular impressions not observed.

Length, 24.5 mm.; greatest width in posterior half 15 mm.; hight from base to beaks, 12.7 mm.; from postero-cardinal angle to antero-basal margin 19.5 mm.; from beak to postero-basal margin 23 mm.; greatest convexity of single valve 5 mm.

This species is related to *M. truncata* Hall, but is less high posteriorly, and more ventricose. It also has a narrower hinge plate and thinner shell, while the surface markings are also somewhat different.

Position and locality; Lower beds of the Cincinnati group, near Cincinnati, Ohio, at an elevation of about 100 ft. above low water mark in the Ohio river.

Modiolopsis alata, n. sp.

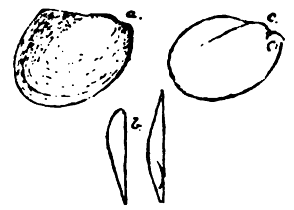

Fig. 8. *Modiolopsis alata* n. sp., Cincinnati group, Cincinnati, Ohio. *a*, and *b*, three views of a right valve preserved in shale. *c*, view of the right side of a free cast of the interior showing the small anterior scar. The rounding of the postero-cardinal region is probably due to attrition.

Shell small, transversely subovate, or Aviculoid in outline, alate and much the widest posteriorly. Valves appressed, with point of greatest convexity above the center. Cardinal margin straight, its length equalling two-thirds of the greatest length of the shell. Anterior end forming nearly a right angle with the hinge line, then rounding gently into the basal margin, the curve of the edge being very nearly uniform from the antero-cardinal angle to the postero-basal region. Here the margin rounds quickly up into the posterior edge, the curve becoming gradually less to the angular junction with the hinge line, which it meets at an angle of about 115°. Beaks small, projecting very little above the hinge line, and situated about one-fourth of its length from the anterior end of the shell. Umbonal ridge inconspicious, only appreciable because of a slight concavity in the cardinal slope. Surface with faint concentric lines of growth. Anterior muscular impression, as seen in casts of the interior, circular and small, but clearly defined.

The largest specimen seen has the following dimensions: Length of hinge line, 12 mm; length from antero-cardinal angle to postero-basal margin (greatest length of shell) 17 mm; greatest hight, from center of basal margin to posterior extremity of hinge line, 13 mm; greatest convexity of two valves 4.5 mm.

Hall's *M. aviculoides* is a narrower and more convex shell The species also resembles *M. truncata* Hall and *M. parva* of this paper. The first, however, is much larger, has a wider anterior end and a thicker shell. The second also has a thicker shell and is much more convex.

Position and locality: Rather rare in yellowish shales of the Cincinnati group, near the tops of the hills about Cincinnati, Ohio.

Modiolopsis parva, n. sp.

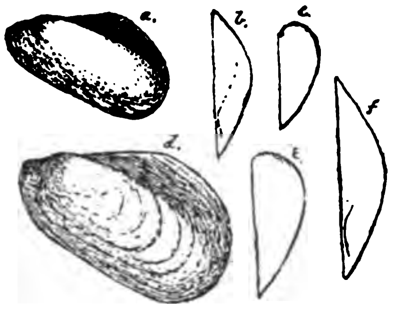

Fig. 9. *Modiolopsis parva*, n. sp. *a*, left valve ×2.5, w [illegible] ior end a little longer than usual. *b*, and *c*. cardinal an [illegible] pro of same. Trenton group near Burgin, Ky. *d*, a left valve fr lower beds of the Cincinnati group at Covington, Ky., also ×2.5, e [illegible] *f*, end cardinal profiles of same. The minute radiating striæ which occur on the posterior half of well preserved specimens are not shown.

Shell very small, obliquely subovate and somewhat Aviculoid in outline, much the widest posteriorly; greatest hight and length, respectively, as three is to five. Valves strongly convex, with point of greatest convexity above the center. Anterior end small, apparently not contracted in front of the beaks, narrowly rounded and often subangular at the anterior extremity of the hinge line. Central portion of basal margin straight, with the curves at the ends, where it rounds up into the anterior and posterior margins, equal. Posterior margin broadly rounded, the upper portion nearly parallel with the basal margin and forming an angle of about 140° with the cardinal line. Hinge line straight, extending nearly to the anterior extremity of the shell. Beaks small, nearly one-third of the length of the hinge from the anterior end. Umbones prominent, the umbonal ridge strongly rounded, extending to a point a short distance behind the center of the valve where it becomes obsolete. Cardinal slope flattened or slightly concave. Surface smooth or marked with obscure, irregular, concentric furrows or striæ, scarcely traceable in the cardinal and posterior regions, where good shells exhibit instead exceedingly fine and crowded radiating striæ. Shell substance comparatively thick. Interior not observed.

Greatest length of the largest specimen seen, 12 mm.; length of hinge line, 8 mm.; greatest hight measuring across the shell at right angles with the hinge line, from its posterior extremity, 8 mm.; distance from same point to center of basal margin, 7 mm.; greatest convexity of single valve, 2.5 mm. In a smaller example from the "Modiolopsis bed" of the Trenton of central Kentucky, the same series of measurements give, respectively, 9, 6, 5.7, 5, and 2 mm.

The small size, straight hinge, Aviculoid outline, great convexity, and comparatively thick shell are the distinguishing features of this species. *M. alata*, of this paper, bears some resemblance to it, but is a much less ventricose and mor delicate shell.

Position and locality: The original specimens are from the Cinci nati group at Covington, Ky., where they were found at an elevation about 150 ft. above the Ohio river. A specimen, represented in the cut by *a*, *b* and *c*, was lately collected in the "Modiolopsis bed" of the Trenton near Burgin, Ky.

Modiolopsis angustata, n. sp.

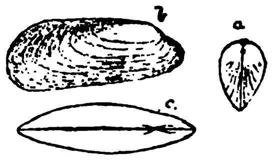

Fig. 10, *Modiolopsis angustata*, n. sp., lower beds of the Cincinnati group, at Covington, Ky. *a*, *b*, and *c*, three views of a specimen of this species.

Shell small, elongate, a little the widest posteriorly, the length equal to two and one-half times the greatest width. Cardinal and basal margins nearly straight, sub-parallel. Anterior end contracted in front of beaks, somewhat extended, with the extremity curved abruptly. Posterior end convex, the upper half rounding gently into the cardinal margin, the lower half the most prominent and with the curve more pronounced. Beaks short, flattened, slightly incurved, situated about one fifth of the entire length of the shell from the anterior extremity. Body of shell moderately convexed, with a but slightly developed umbonal ridge; central portion flattened from the beaks to the basal margin, not enough however to cause the latter to become sinuate. Point of greatest convexity a little above the center of the shell, cardinal slope, very slightly convex or flat. Surface marked with small irregular concentric furrows, strongest centrally, and much finer lines between them.

Length 23.5 mm.: greatest hight (at posterior extremity of hinge line) 9 mm.; hight at beaks, 7 mm.; convexity of the two valves in conjunction, 6 mm.

This species resembles *Orthodesma* in its elongate form and unusually extended (for *Modiolopsis*) anterior end. In all other respects however, it agrees very well with typical species of this genus.

The New York Trenton species *M. mytiloides* Hall.(Pal. N. Y. vol. I, p. 157, Pl. 35, fig. 4) may be a closely related species. The figures show it to be a more convex shell, with shorter anterior end, more pronounced umbonal ridge, and more oblique posterior margin. The cardinal and basal margins are also less nearly parallel. An undescribed species occurring in the upper beds of the Trenton of central Kentucky, is more closely related.

Position and locality: Rare in the lower beds of the Cincinnati group at Covington, Ky.

LEO LESQUEREUX.

By Edward Orton.

The revocation of the Edict of Nantes inflicted an irreparable injury upon the French nation in depleting it of its middle class, from which its industrial energy, its science, literature and art were mainly drawn; but the Protestant neighbors of France gained correspondingly thereby. England, Holland, Switzerland and the English colonies in North America were greatly enriched by this enforced emigration. These Huguenot exiles brought unique and invaluable contributions to the countries in which they found refuge,—intelligence, strong convictions and the courage to maintain them, skill and taste in handicraft, and gracious manners the charm of which was everywhere recognized. They at once became loyal subjects of the governments that sheltered them and their contributions to the public service soon became out of all proportion to their numbers. For example, of the seven presidents of the congress that sat in Philadelphia during the revolution, three were of Huguenot parentage.

It was from this stock that Leo Lesquereux sprung, and by its training and traditions his early life was shaped. His ancestors, when driven from France by the revocation, established themselves in the Swiss canton of Neuchatel and here, in the village of Fleurier, on the 18th of November, 1806, Leo Lesquereux was born. His father was a manufacturer of watch springs, owning a small factory and employing four or five workmen therein. His mother was well educated and had a great love of knowledge and great respect for superior attainments among those whom she met. She insisted that her son should have the best education available, hoping to see him enter the ministry of the Lutheran church.

From his early childhood he had an enthusiastic love of nature and especially of the sublime scenery that surrounded his

Respectfully yours
Leo Lesquereux

home. To scale the most difficult summits and to gather the rare flowers that grew there, were among his early ambitions and pleasures. He must have been a daring climber. On one of his excursions, when about ten years of age, he met with an accident of so dangerous a character that his escape from death seems almost incredible. He had climbed the mountain that towers above Fleurier, but by a misstep he fell over the edge of a cliff, down the steep mountain side. He struck first upon a projecting ledge and was rendered insensible by the fall; from this point he rolled limp and unresisting, his descent being occasionally checked by branches of trees or shrubs, to the borders of the meadowland far below. When picked up there, he was found fearfully bruised and lacerated, but no bones were broken. For two week he lay unconscious, but at the end of six weeks he was on his feet again, the only permanent injury being a partial loss of hearing in one ear. The total deafness that overtook him in early manhood was no doubt connected in origin with this fearful fall. The council of the village had the wonderful story entered on its records and the cliff from which he fell was marked by a flag for a long time thereafter.

At the age of thirteen he was sent to Neuchatel to begin his academic course. It was due altogether to his mother that he took this course, the lad himself preferring to remain at home and learn his father's trade. On entering school, child though he was, he was obliged to learn from the first the art of self-help. He earned enough to buy the books which he used by teaching pupils younger or less advanced than himself.

Among his fellow students were two others to whom he was especially drawn, Arnold Guyot and August Agassiz, both of them of the same French Puritan stock to which he himself belonged. Louis Agassiz, an older brother of August, was now carrying forward his studies in the German universities, but was soon to return to Neuchatel as a professor. With Guyot in particular, young Lesquereux established the closest relations of friendship and sympathy, which were terminated only by the death of the former in an honored old age, While students, they were inseparable in term time and vacation alike. The academic curriculum at Neuchatel was of the old type, as a matter of course. There was but one type known at this time it was mainly made up of the classical languages and literatures, of mathematics and philosophy. The course was severe and the training rigid and thorough. Young Lesquereux became a good classical scholar, even according to the high standard that then prevailed. He read Latin and Greek at sight and wrote Latin with facility to the day of his death. To accomplish these things costs strenuous labor,—there is but one road that leads to such results. His day's work as a student often covered fourteen, or even sixteen hours. Throughout his course he was obliged to eke out a scant allowance by giving private tuition to his juniors in the college, but this work paid him not alone in the money he earned, but in a firmer hold on the subjects which he taught.

It fell out in his after life that he made comparatively little direct use of what he learned at such an outlay of time and force in his college days; but he never regretted the severe discipline to which he had been subjected. He ascribed to it, in fact, a large measure of the success that he afterwards attained in widely different fields.

At the end of a seven years residençe at Neuchatel, he had completed his academic course, and aside from a genuine and even enthusiastic love of nature, he had not come in sight of natural science. We hear nothing more of the study of theology and it is probable that he gradually drifted away from the end to which his earlier studies were directed. The love of learning had been awakened in the youth and he could not rest content at the point where he was left by his collegiate course. He resolved to continue his studies in a German university, but in compassing this result he must depend upon his own resources.

The easiest way for the youth just out of college to earn money was by teaching others what he had himself learned, and the easiest thing for him to teach was his native tongue and for this, happily, there was a good market at that time. French was the language of diplomacy and culture throughout Europe and a knowledge of it was indispensable to all who would advance in politics or shine in social life.

Young Lesquereux found it easy to secure an engagement in Germany as instructor in French. He became private tutor in a noble family in the city of Eisenach, Saxe Weimar. The duties of instruction that he assumed required but a part of his time and he was at liberty to use the balance in private tuition.

The best families of the city furnished him his pupils. Among the households into which he was thus called was that of a distinguished soldier of noble birth, general Von Wolffskel, an attaché of the court of the duke of Saxe Weimar. The general's daughter, beautiful and highly educated according to the standard of the time, became his pupil. She made great proficiency in French, learning to speak it with as much facility as her native tongue; but both teacher and pupil managed to acquire another language during this tuition, new to them, but old as the human heart. When his year was finished and he was about to return to Switzerland, the young tutor summoned courage to ask the parents for the daughter's hand. The mother was thunderstruck by his audacity, but the old general took a kindlier view. Before answering the question, he determined to become personally acquainted with the suitor and finding the date on which he expected to set out for Switzerland, he made an errand to the southward himself, taking the young tutor along with him in his carriage. As they drove for several days through the beautiful Thuringian forest, the wise and wary general sounded as best he could the intellectual resources, the tastes and character of his prospective son, revealing himself, as well, by his questions to the latter. The test was well met on both sides, and when general and tutor bade each other farewell, the foundations for a genuine mutual respect that lasted with each as long as life, were well laid, and moreover there was a new bond between them. Mr. Lesquereux was to return to claim his bride when he could show his ability to support her. Much of the remainder of the journey to Switzerland he made on foot, but his heart was light and his hopes were high.

After his return, he soon obtained a position as teacher in the High School at Locle, at a salary of three hundred dollars a year. Presently he made a step in advance by gaining the principalship of the High School of the College of La Chaux de Fonds which brought him three hundred and sixty dollars a year. The latter place he won by sustaining a most rigorous competitive examination, continuing through an entire week. There were twenty-one competitors on the first day; there were but two left for the last day. In preparing for this examination, all the time he had been able to command during the previous three months had been industriously used.

Obtaining from the trustees permission to increase his salary by giving private lessons out of school hours, and securing enough of such work to make his prospective income five hundred dollars per year, he felt warranted in returning to Eisenach for his bride.

Mr. Lesquereux touched high life at several points through this new connection. Gœthe was for forty years a member of the same court to which his wife's father belonged, and during her childhood she enjoyed the special notice and even the friendship of the great author. The family still prize the correspondence which Gœthe maintained with his childish friend.

Prince William, afterward to become the great German Kaiser, came also to this court to find his wife, viz., Augusta, the daughter of the grand duke of Saxe-Weimer—Eisenach. At the wedding, Mrs. Lesquereux was a bridesmaid and when a little later she herself wore the bridal veil, a young lieutenant of the army, Von Moltke by name, was the bridegroom's "best man:" the lieutenant became the greatest general of modern times.

In the second year of Mr. Lesquereux's married life the trouble in his hearing, the foundation of which was laid in the perilous fall of his childhood, rapidly increased. He suffered great pain during the progress of the disease. At time she became totally deaf, but would then secure partial though temporary relief. Finally, after a brave and persistent effort to carry on his teaching, he was obliged to resign his position. Still hoping for restoration, he consulted an eminent physician in Paris, at whose hands he suffered treatment that would now expose anyone who should employ it to the charge of malpractice. By it Mr. Lesquereux was thrown into brain fever and when he recovered from this, he was obliged to recognize the dreadful fact that he was hopelessly and incurably deaf.

These facts required a new arrangement of his life. Nothing seemed open to him at first but manual labor, and to this he turned with a cheerful courage that was most honorable to him. The change meant a great deal to himself and more to his wife, for it involved one of the most costly sacrifices that we can be compelled to make, that, namely, of social position. The bridesmaid of a queen finds herself the wife of a mechanic. The trade selected was that of engraving watch cases. He bought a turning lathe and applied himself diligently to the work; but with all his efforts, laboring from six in the morning to ten at night, he could earn in the beginning but one dollar a day. On this pittance he was obliged to support his high-born wife: she showed herself, however, as brave as her husband. Just as he was becoming a master of this calling to such a degree that he could earn a better living by it, he was obliged to abandon it on account of its effect upon his health.

At this juncture his father came to his relief, and offered him a partnership in the small factory, if the son would first spend a year in learning the trade. Nothing was left for the brilliant young scholar and teacher but an apprenticeship in which the veriest village hinds stood on equal footing with himself. He passed this ordeal successfully, gained the partnership in due time and became relatively independent once more. But at this period, his life judged by all ordinary standards would have seemed to be a disastrous failure. His deafness had driven him from his profession and from society, and the only calling that appeared to open before him was a very humble one: but his mind was active and he gave himself constant occupation in the world of literature during all his spare hours. By some chance he was drawn to the study of botany and especially to the division of the mosses. This is his first direct connection with science. He had but little time for such pursuits,—Saturday afternoon and Sunday of daylight for collection, but entire nights he made use of for study. He managed to buy a microscope and to begin the systematic examination of this family of plants. His natural gifts asserted themselves here and it was not long before the young mechanic was quoted as an authority on mosses. He had found at last his calling, though he did not know it yet.

About this time the gradual reduction of the forests of the Canton led the Government to new interest in the peat bogs, which furnished the larger part of the fuel of the poorer classes. In the carrying out of this interest the Government offered a prize, a gold medal valued at twenty ducats, for the best essay on the formation and preservation of peat. Mr. Lesquereux determined to compete for this prize. Making arrangements with his father, by doing extra work on certain days, he obtained a larger amount of daylight for his outdoor studies, and was able for a few months to employ Saturdays, Sundays and Mondays as well in this way. He probed the peat bogs with instruments of his own devising, he determined their rates of growth and decay and the conditions of moisture and temperature that prevailed in them. So unintelligible did his new interest appear to the simple minded people among whom he dwelt, that he was even thought to have gone daft and was beginning to be called the "fool of the peat bogs." The manuscripts of the competing essays were sent in. Mr. Lesquereux's essay was found by far the most exhaustive and valuable and the prize was easily awarded to it. This was a great triumph and his loyal wife was as happy as he in the result. It had mainly been written in the dingy little factory where his days were spent; and most of it, so far as the composition is concerned, while his hands were busy with the mechanical work that claimed them. To this report, all of our sound and valuable knowledge as to this important subject must be referred back.

[illegible] of his new studies was the form- [illegible] the illustrious Agassiz who [illegible] history in the Academy [illegible] the Government [illegible] that were embodied [illegible] of the committee profes- [illegible] at first accept all the [illegible] commission traveled from [illegible] he began to see that Les- [illegible] of the philosophy as well [illegible] of the author's views. [illegible] through the trammels [illegible] of his powers. [illegible] work than drilling [illegible] a man of science and [illegible] of the canton [illegible] work on peat bogs for the [illegible] hundred dollars for the [illegible] office was created, that of director of peat bogs, and Mr. Lesquereux was appointed to fill it. He wrote also two other treatises upon the same general subject. As his fame extended, new and more responsible work was brought to his hands. The king of Prussia commissioned him, moved in part thereto by the ties of friendship which Mrs. Lesquereux could plead with queen Augusta, to explore and report upon the peat bogs of Germany, Sweden, Denmark, Holland and France. This errand gave him the unusual advantage of extensive travel and wide observation under letters royal. To these tours also he owed the extensive personal acquaintance with the scientists of Europe that served him so well through the remainder of his life.

The political changes that were sweeping through Europe in 1847 and '48, affected even the governments of the little Swiss cantons. By these changes, Mr. Lesquereux's scientific work under the auspices of the State was arrested. Professor Agassiz had already been attracted to the United States by the splendid opportunities for advancing science that were offered to him here, and Guyot and Lesquereux followed in the next year, viz., 1847. To these three compatriots and lifelong friends American science owes a great debt. All have passed to honored graves, but in countless ways their works still follow them.

Dr. Lesquereux was forty years of age when he reached this country. Though in the prime of life as years are counted, he was totally deaf. In his native tongue he could maintain a conversation so well by following the movement of the speaker's lips, that a stranger might not at once discover his infirmity. But our stubborn English tongue foiled him in this respect, and when it was employed, he was generally obliged to use pencil and paper in his conversation. Moreover, he had acquired our language without ever having heard it spoken and though he wrote English with force and precision, thanks to his early linguistic training, one needed to become accustomed to his pronunciation to follow him readily as he spoke it.

His first scientific work in this country was done for professor Agassiz. It consisted of a classification of the plants gathered by the latter in his Lake Superior expediton. While engaged in this work, and frequently for months at a time he was a member of Agassiz household. His report was published in 1848.

At the close of the same year, he was called to Columbus where he made his home for the remainder of his life. The circumstances under which he came to Columbus deserve to be mentioned, as they bring to light a history that has had few counterparts in the country hitherto. By the publication in 1845 of the *Musci Alleghanienses*, Mr. William S. Sullivant of Columbus had put himself at the head of American bryologists, and was so recognized at home and abroad. The scientific collections of the Government in this department were coming into his hands for study and the field was in every way widening before him, bringing him more than he could do unaided. He was a gentleman of large fortune and was therefore not obliged to ask even a living from science. All of his work was done at his own charges, and most of it was published in a like manner. It was distributed among his fellow laborers in science with princely munificence. Mr. Sullivant called to his aid Mr. Lesquereux and for many years thereafter, even to the date of Mr. Sullivant's death, the foremost bryologist of America and one of the most accomplished bryologists of Europe worked side by side, in the completest accord and harmony, with mutual respect for each other's acquirements and results. They effected thereby an immense advance in this department of science and made all future students of American bryology their debtors. Mr. Lesquereux was employed by Mr. Sullivant for one or two years and was afterwards aided in various ways in carrying forward his work by the generosity of his friend. They published together the two editions of *Musci Exsiccati Americani*, the first edition in 1856 and the second in 1865. Mr. Lesquereux also had much to do with the crowning work of Mr. Sullivant's life, the splendid *Icones Muscorum*. The Latin text is in part his work, and the publication of the second volume was carried forward under his direction after Mr. Sullivant's death.

Mr. Lesquereux's career has been followed thus far without a single reference to the department of science in which by far his most important work was to be done, the department, namely, of paleobotany. His interest in this subject began before he left Europe. While still in Switzerland, he had acquainted himself with the foundations of fossil botany laid by Brongniart and others; and as early as 1845 he began to publish observations of his own in this field. But his real work in paleobotany began about 1850. A passing reference of Brongniart had suggested the view that coal-seams originated under conditions similar to those in which peat bogs are now formed. In the mind of one who knew more of peat bogs than anyone had ever known before, the suggestion took root and expanded into a theory which covers the origin of by far the largest part of our valuable accumulations of coal. The theory, variously supported and reinforced by American facts though not without grave difficulties, holds decidedly the first place today among the theories of coal formation in the geological world.

But it was not in the theoretical subject of coal formation, many of the problems pertaining to which are difficult and perhaps for the present insoluble, that Dr. Lesquereux's great work was to be done. It is the plants, high and low, that have covered the earth in the past, and especially those assemblages of them which we denote coal floras, that were to be illustrated by his patient labor and illuminated by his wide and increasing knowledge. Attached to the descriptions of a great number of these fossil plants, including many of the most abundant and important of the most valued floras of all time, the cabalistic letters "Lsqx." will remain as long as paleontological science is cultivated. Dr. Lesquereux's labors covered the great Appalachian coal field, as it occurs in a half dozen states, and from the bottom of the series to its summit. Equally fruitful were his studies of the floras of the later coals.

The most valuable single contribution that he has made to paleobotany is unquestionably "The Coal Flora of Pennsylvania", published by the Second Geological Survey of that state. There is no other American work on the subject that is even to be named in comparison with it. It was written when the venerable author had long passed his three score years and ten, and while embodying all his knowledge and experience, it shows no signs of flagging strength or failing powers. A list of his most important contributions to science will be given at the close of this paper. It stands for a prodigious amount of labor of the highest grade, accomplished under the fearful disadvantage of total deafness.

For the last forty years, the name of Leo Lesquereux has been known and honored throughout the scientific world. He was made a member of a score of the leading scientific societies of Europe and was the first elected member of the National Academy of Sciences, of the United States. In 1875, he received the degree of Doctor of Laws from Marietta College. He maintained intimate relations by a constant and most kindly correspondence with all the leading paleontologists of Europe. Oswald Heer, in particular, was one of his most valued friends and when his death occurred a few years since, Dr. Lesquereux felt as if a brother had been stricken down. Professor Guyot's departure impressed him in the same way. The death of his beloved wife occurred not far from these dates and the world began to look empty to him. The sentiment *jampridem inutilis annos demoror*, began to find frequent expression in his conversation. "I belong to a past generation," he would say, "my friends and contemporaries are all gone; for what do I remain?" But, although almost impatient for the summons to cross the bar, he never for a monent lost his serenity and never, until the busy brain at last gave way, abandoned his tasks. He died in his modest home in Columbus, October 25, 1889, aged nearly 83 years.

He was modest in his estimate of his own work. All the knowledge that has been attained in the departments of which he knew most, seemed, in his later years, very small to him. "*I* know a *little*," he sometimes said, "other students of science know each a little, but the whole of what is known is but fragmentary and insignificant,—merely a few pebbles picked up along the ocean shore."

Dr. Lesquereux was a devout Christian believer; he lived and died in the communion of the Lutheran church. He extended his creed to take in all scientific discoveries, but he did not count any of its essentials disturbed thereby. He seems never to have been reached by the currents of modern thought which have overflowed the old foundations for so many.

It is a pleasure to add that his noble library, largely composed of presentation copies of the most valuable paleontological works of the last half century, will be maintained intact. It has been purchased with this intent through the enlightened public spirit of P. W. Huntington, Esq., of Columbus, and will be placed where it can be fully available for the purposes of science.

Dr. Lesquereux was personally known to but few residents of the city in which the last forty years of his life were spent, but he was respected and honored by a much wider number and there were many that felt, when he was borne out of his humble cottage to his last resting place that an illustrious citizen had passed from among us.

The facts for this sketch have been derived from conversa-

tions with Dr. Lesquereux, from his son, Leo Lesquereux, Jr., from an excellent sketch in the Mute's Chronicle, January 15, 1887, and from a valuable article prepared by Miss Lida R. McCabe for the Popular Science Monthly, April, 1887.

LIST OF SCIENTIFIC PUBLICATIONS[1] OF DR. LEO LESQUEREUX

Catalogue of Mosses of Switzerland. Natural History Society, Neuchatel, 1840.
Explorations of Peat Bogs, Prize Essay Neuchatel.
Directions for Exploration of Peat Bogs, 1844.
Botany of the Lake Superior Expedition, 1848,
New Species of Fossil Plants, Journ. Nat. Hist. Boston, 1854.
Paleontological Report, 1st Penna. Survey. 1857.
Paleontological Report, Kentucky Geol. Rep't. Vol. III, 1857.
Paleontological Rep't. Kentucky Geol. Rep't, Vol. IV, 1861.
Catalogue of Fossil Plants of Coal Measures of Penn'a. 1858.
Paleontological and Botanical Report, Arkansas Geol. Rep't 1860.
Paleontological and Geological Rep't of Indiana 1862.
Paleontological Report of Illinois, Geol. of Illinois, Vol. II, 1866.
Paleontological Report of Illinois, Geol. of Illinois, Vol. IV, 1870.
Catalogue of California Mosses, American Philos. Soc. Vol. XIII, 1864.
Tertiary Fossil Plants of Mississippi, Am. Philos. Soc. Vol. XIII. 1864.
On Fucoids in Coal. Am. Philos. Soc. Vol. XIII, 1864.
Pacific Coast Mosses in California, Acad. of Science 1868.
Musci Exsiccati. 1st Edition, (with W. S. Sullivant,) 1856.
Musci Exsiccati, 2d Edition. (with W. S. Sullivant) 1865.
U. S. Geol. and Geogr. Survey of Terr. Rep'ts of Hayden, 1870-1-3.
Cretaceous Flora of Dakota Group. (same as above) 1874.
Review of Fossil Flora of North America, Penn. Monthly 1875.
Coal and Coal Flora. Encyclopedia of North America.
Latin Text of Supplement to Sullivant's Icones Muscorum, 1874.
New Species of Teritary Fossil Plants, U. S. Geol. and Geog. Survey. Hayden's Bulletin 52, 1875.
New Species of Cretaceous Fossil Plants, U. S. Geol. and Geog. Sur. Hayden's Bulletin 52, 1875.
Cretaceous and Tertiary Floras of Western Territories, Hayden. 1874.
Fossil Marine Plants found in Carboniferous Measures. Geol. Sur. of Indiana. 7th Ann. Rep't, 1876.
Plants of the Silurian. Philos. Soc. of Phila. 1877.
Contributions to Fossil Flora of Western Territories. U. S. Geol. and Geog. Survey. Tertiary Flora, 1877.
Pliocene Flora of Auriferous Gravels. Mus. Comp. Zool., Cambridge, 1878.
Catalogue of Fossil Plants of Tertiary and Cretaceous, Hayden 1878.
On Cordaites. Amer. Philos. Soc. 1878.
On a Branch of Cordaites bearing fruit, Amer. Phil. Soc. 1879.
Coal Flora, Atlas and Text. 3 vol. 2d Penna. Survey 1879-1884.
Manual of American Mosses. (with Thomas P. James) 1884.
Cretaceous and Tertiary Flora of the United States, Geol. and Geog. Survey of Territ. Vol. VIII, 1883.
Principles of Paleozoic Botany. Geol. Rep't Indiana, 1884,
Vegetable Origin of Coal, 2d Geol. Sur. of Penna, 1885.
Papers in American Journal of Science.
    Divers questions concerning Coal, 1860.
    Fossil Fruits of Branden Lignites, 1861.
    Some Fossil Plants of Recent Formations, 1859.
    Some Fossil Plants of John Evans, 1859.

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[1] Titles not all given in full, and not verified in all cases, but will serve as a clue.

Origin and Formation of Prairies, 1865.
Formation of Lignite Beds, 1874.
Land Plants in the Lower Silurian, 1874.

[NOTE. Several of Dr. Lesquereux's works await publication. ED.

ARTESIAN WELLS IN KANSAS AND CAUSES OF THEIR FLOW.

By ROBERT HAY, F. G. S. A., Junction City, Kansas.

Read before the Kansas Academy of Science, Wichita, October, 1889.

There are wells yielding artesian flow of water in many parts of Kansas. The following may perhaps be considered the principal places: Fort Scott in Bourbon county, Mound Valley in Labette, St. Mary's and Wamego in Pottawatomie, Lawrence in Douglas, northwest of Alma in Wabaunsee county, at the east line of Cloud county, Oberlin in Decatur, near Great Bend in Barton, Larned in Pawnee, on Crooked Creek in Meade, at Richfield in Morton, and Coolidge in Hamilton county.

These wells are of all depths from less than fifty feet to six hundred and more. The water comes from rocks of different geologic periods. It is of very different kinds, from soft water, pleasant for domestic use through others of moderate hardness to some that are highly mineralized and of more or less medicinal quality. Some are decidedly saline.

The largest flow in the state is at Larned. There a strong brine rushes to the surface with great force to a hight of over fifteen feet. It spouts forth from a depth of four hundred and thirty feet and more at the rate of from 250 to 300 gallons per minute. It is used for medicinal purposes and for swimming baths. A part of its waste may be seen from the railway in the form of a fountain more than ten feet high.

Wells at Coolidge nearly three hundred feet deep are obtaining from Dacotah sandstones a supply of good water but slightly mineralized. The largest, yielding one hundred gallons per minute is utilized for the city water-works. Others, giving out each about fifty gallons per minute are used for irrigation and watering stock. There is one of small flow—six or eight gallons per minute—also used for irrigation.

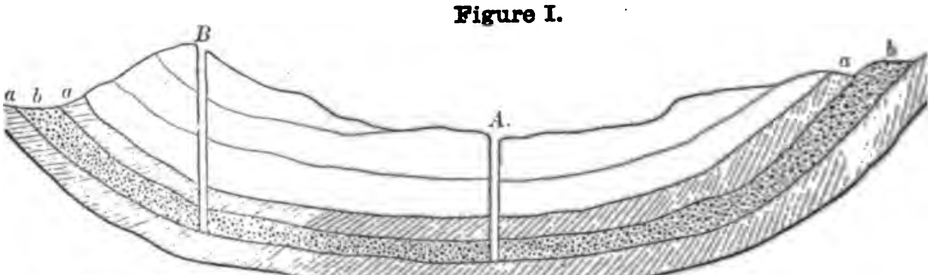
In Meade county there is a group of wells in an area of several square miles that at depths varying from fifty to one hundred and eighty feet yield a good water suitable for domestic purposes in quantities varying from three or four gallons per minute to over sixty. The largest yields 66 gallons per minute and on another farm there are three wells with an aggregate flow of 98 gallons. Some, but not nearly half, of the water of this district is used for irrigation and two of the proprietors turn it into carp ponds. This water is obtained from debris of the miocene grit probably broken up in pliocene time and covered by a light blue impervious clay. The grit outcrops on the edges of neighboring high prairie; the wells are all in the valley, so the source and course of the water are easily determined.

The wells in Hamilton, Meade, and Pawnee counties owe their waters and their force to the usual causes of artesian flowage. These are, the not very distant outcrop of porous strata catching the rainfall of a considerable area, the dip of these porous strata towards the wells and the overlying and underlying impervious beds of clay or clay shales. These conditions are illustrated in the diagram. (See page 298.) The cause of the flow may be called HYDROSTATIC PRESSURE.

The artesian flow at Mound Valley in Labette county is a remarkable example of another force. The well was bored for gas or coal. Water was encountered at two places in the first hundred feet and a small quantity of gas at 203 feet. At 277 feet there was a copious inflow of strong brine which rose some distance in the tube. At 449 feet there came a flow of gas so powerful that it lifted the column of water to the surface and maintained it as a flowing well. This example is a good one of GAS PRESSURE as an efficient cause of artesian flow. There are other wells in which this is a probable cause also, but not so certainly indicated as in this case. These might be called gas artesian, or in more direct reference to their cause *gas pressure* wells.

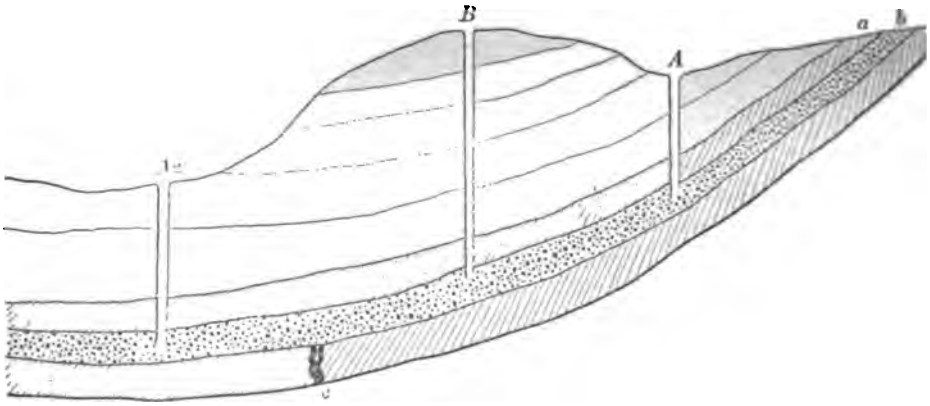
There is besides the true artesian wells and those which we have called "gas artesian" another class of wells which have the artesian flow, but which do not seem to be accounted for by the principles illustrated in either of those groups. These wells have two characteristics in common: they are *deep* wells, and they have only a *small flow.* There are doubtless some others but there are three which will serve to illustrate what we have to say. They are at St. Mary's and Wamego in Potta-

Figure I.



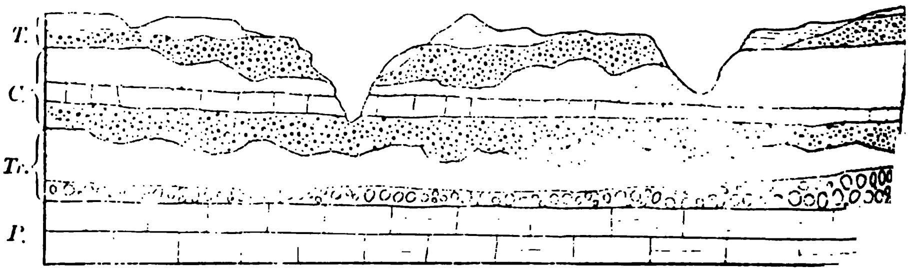
a. a. Impervious beds dipping towards center of basin, inclosing porous bed (*b*).
A. Well near center of basin with artesian flow.
B. Well on higher ground without artesian flow, because located higher than the outcrop of *b*.

Figure II.



A B. a b. As in Fig. 1.
c. Breach in the continuity of the lower (*a*) impervious bed.

Figure III.



T. Tertiary. *1.* Pliocene marl. *2.* Miocene grit.
C. Cretaceous. *1.* Niobrara. *2.* Benton. *3.* Dacotah.
Tr. Trias. *1.* Red Beds. *2.* Salliferous horizon.
P. Permo-carboniferous.

THE USUAL RELATIONS OF STRATA IN WESTERN KANSAS.

wotamie county and at Richfield in Morton county. They each have another quality in common, but this is also common to all deep wells whether artesian or not, viz: the water is highly mineralized. That of the Pottawotamie wells is strongly saline, that of Richfield is without the salt, but has iron and other ingredients.

The artesian water at Wamego comes from a depth of 300 feet (289 to 304). That at St. Mary's in the same well (there are several flows) is from depths of 454, 675 and 958 feet. That at Richfield is from a depth of just under 600 feet. The flow at Richfield is 6⅓ gallons per minute. The wells in Pottawotamie county have not had their flow measured but no one of them exceeds that at Richfield: they appear to be much less.

In at least one of the St. Mary's wells there is a suspicion that gas may help to sustain the column of water, but there is no such appearance at Wamego, and at Richfield the case is the same.

The Pottawotamie wells are in paleozoic (Coal Measure) strata. The Richfield well is in Mesozoic, the principal part being in Dacotah, and Red beds (Triassic) with a little Tertiary at the top. In neither of these cases do we have ***apparent*** the conditions of an ordinary artesian well. We have not seen an outcrop nor recognized a dip of strata that would point to the source of the flow as in ordinary cases. Diligent enquiry has not revealed that other persons have recognized suitable outcrops. The outcrop of the paleozoic strata is to the east of St. Mary's and there the surface of the country is lower than in Pottawotamie county. A possible outcrop for the Wamego sandstone horizon might be found in the highland south of the Kaw river and east of Topeka, but the St. Mary's wells give no water at that depth and they are nearer that outcrop though not in the exact line of the dip. The outcrop of the St. Mary's water horizons can only be found much farther east where the surface is lower than at the wells. The outcrop of the Richfield water horizon must be looked for to the west. The land is higher in that direction but the outcrop of the horizon which is here 600 feet deep must be at a distance too great to warrant the looking to this outcrop as the source of the well.

It would seem then that in these wells of small output from considerable depths some other than the usual causes of artesian flow must be looked for. We think that there is a cause ready to our hand sufficient for all such phenomena. It is always in operation and might be expected sometimes to produce such results.

This cause we will call *rock pressure.* All rocks in the earth's crust contain some water. The more porous rocks contain the greater quantity. At a distance below the surface the superincumbent strata subject the rock masses to enormous pressure. If we assume that the rocks of Kansas to a depth of one thousand feet have an average specific gravity three times as great as that of water we are probably within bounds, as, though limestones and sandstones are usually somewhat less, the presence of iron in many of the beds will bring up the average considerably. On this basis a prism of the rocks to the depth of 600 feet and one inch square would weigh 781 pounds, which is equivalent to a pressure of 52 atmospheres. If, then, 25 feet be taken as the measure of a column of these mineralized waters equivalent to one atmosphere, the rock pressure would be more than the equivalent of a column of water twice this hight.

Let a water-bearing stratum at a depth of 600 feet as at Richfield, be pierced by the drill we should then have the rock pressure of 52 atmospheres squeezing the water out of the rock pores and, granting sufficient plasticity in the rock and a sufficient quantity of water, it must rise in the tube which has only the pressure of one atmosphere upon it. A large bore to the well and a small supply of water would be against its reaching the surface. On the other hand a bed rock with mobile molecules at or near saturation, under this enormous pressure must cause in a narrow tube a flowing well. At 300 feet the rock pressure would be only half that given above or 26 atmospheres and the column of water to be supported will be diminished in proportion. At other depths the same proportions will hold good.

Here then we have a force that may be merely an aid in some cases of artesian flow which is mainly due to the usual causes of such flow, and which is a most efficient cause for the constant flow of wells whose depth is great and whose quantity of water is small. We are inclined to consider *rock-pressure* as the cause of the flow of the Pottawotamie and

Morton county wells, at least till future search shall make more probable that it is due to the usual causes of artesian wells.

At some future time we may endeavor to classify all the artesian wells of Kansas with reference to the efficient causes of their flowage. At present we must be content with here suggesting the three forms of *hydrostatic*, *gas*, *and rock-pressure* as these efficient causes and especially to call attention to the last two in the cases of deep wells of small outflow.

CRYSTALLOGENESIS.

By Dr. H. Hensoldt.
School of Mines, Columbia College, New York.

I.

"We live in that predicament that our facts have outstripped our knowledge and are now encumbering its march. The publications of our scientific institutions and of our scientific authors overflow with minute and countless details, which perplex the judgment and which no memory can retain. In vain do we demand that they should be generalized and reduced into order. Instead of that the heap continues to swell. We want ideas and get more facts. We hear constantly of what nature is doing, but we rarely hear of what man is thinking. We are in possession of a huge and incoherent mass of observations, which have been stored up with great care, but which until they are connected by some presiding idea, will be utterly useless."

This passage from Buckles' "History of Civilization in England"[1] is brought to my mind whenever I hear of the discovery of another asteroid, a new mineral, parasite or hitherto undescribed fungus. It would seem as if the vast majority of our observers beheld in the mere recording of trivial facts the sole aim and end of science. Witness the large and pitiful army of our museum-zoologists and herbarium-botanists. Is it because their mental caliber is such that they recognize the hopelessness of any other course in their frantic struggle for temporary notoriety?

Crystallography, on account of its numerous inherent complexities and difficulties is a subject so utterly distasteful to even many "mineralogists" that a general diffusion of its teachings can never be hoped for, yet it is amazing to notice the blindness which prevails even among adepts in reference to some of its features—features which have a direct bearing on the profoundest cosmical problems, and which in scope and grandeur are without a parallel in other departments of science.

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[1] Vol. III, p. 379, London, 1873

One of the most significant discoveries of modern physics—a discovery in which the sciences of mineralogy, optics and molecular dynamics are, perhaps, equally involved—is that of the singular relations which exist between the external shape and the optical properties of crystals. It is not a discovery, which, like the announcement of Kirchhoff's lucky interpretation of the mysterious Fraunhofer lines, has startled us by its suddenness, or indeed one for which we are indebted to the genius of an individual. It was foreshadowed by Newton's great contemporary Huyghens[2] and, in a measure, outlined by Fresnel, Arago and Brewster, though its evolution proper may be said to date from the moment when, in 1814, Wollaston discovered the rings of Iceland spar, and mineralogists, after endless comparisons and angle-measurements, had come to the conclusion that all crystals could be arranged in six groups or systems.

A review of the fundamental facts of crystallography, or mere repetition of what may be found in every elementary text-book, is not here intended. It is taken for granted that the reader is aware of the difference between a tetrahedron and a hexagonal prism, especially in reference to axial relations, still a detailed knowledge of the intricacies presented by the world of crystals is by no means essential to a full comprehension of the points which I am about to present.

We have six crystallographic systems, and it has been mathematically demonstrated by Quenstedt that a seventh is impossible. All mineral bodies, whether compound or elementary, whose form and structure is determined by a symmetrical accumulation of particles in three directions and which present polyhedral boundaries can be arranged in six groups, and no matter what the mineralogy of the future may have in store for us in the way of surprises, the number of fundamental systems will never be increased. An accumulation of particles, development or "growth" in *less* than three directions is inconceivable, and the discovery of a fourth would be equivalent to that of the mysterious "fourth dimension of space" so much talked about and sought after by muddle-headed physicists.

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[2] Tractatus de Lumine. (1690.)

Many a student of Natural History, who has hitherto fought shy of crystallography on account of the mathematical element which is so prominently associated with it, would be startled to observe that behind its grim and uninviting exterior a world of fascination and splendor is concealed, and that in the wealth of its unsolved problems it affords a greater, richer and fuller field for research than any of the old and well-beaten paths of animal and vegetable morphology.

If we consider crystals of every possible shape or dimension in reference to the essential factors by which the distinctive character of each is determined, viz. their axes of symmetry, we are struck by a curious fact. If we afterwards consider the same crystals in reference to their optical properties—so far as the latter can be ascertained by sufficient transparency—the same curious fact is again forced upon our attention and our astonishment is by no means lessened when we find it persistently manifested, no matter in what direction we extend our comparison of general physical relations, such as thermotic, sound and heat-conducting properties, etc. This fact consists in the singular recurrence of the numbers 1, 2 and 3.

A crystal may be defined as an aggregate of particles, accumulated and symmetrically disposed in reference to certain lines or "axes" in obedience to laws which, as yet, are very imperfectly understood. The fundamental number of these axis is three, though for the sake of convenience we assume four in one of our crystallographic systems.

Now when we come to examine these lines of symmetry a little closer, we observe that only *one* system, viz. the isometric, is characterized by perfect axial uniformity; the three axes are of equal length so that either may be regarded as the principal one. In *two* systems, however, only two of the axis are equal and in the remaining three all the axes are unequal. The numbers 1, 2 and 3 are thus manifested in the following:

Axial classification.

One system with 3 equal axes. (Isometric.)

Two systems with 2 equal axes. (Tetragonal and Hexagonal.)

Three systems with 3 unequal axes. (Orthorhombic, Monoclinic and Triclinic.)

Now we find that the crystals of only one system are simply refractive or isotropic. If a pencil of light falls obliquely on one of the faces of such a crystal, it merely experiences a change of direction, but it is not split or divided into other pencils, which diverge and follow different paths. The system which is thus optically characterized happens to be the one in which the three axes are of equal length, viz. the isometric.

The crystals of the five remaining systems exhibit the phenomenon of double refraction, but we observe the curious fact that in two systems simple refraction takes place in one direction only (optically unaxial crystals), and in three systems in two directions (optically biaxial crystals). And what is still more remarkable, the optically unaxial crystals are those of the systems in which two axes are of equal length, while the biaxial are, without exception, those of the systems in which all the axes are unequal. Thus the numbers 1, 2 and 3 are again significantly brought to our notice in the

Optical classification.

One system simply refractive in all directions. (Isometric.)

Two systems simply refractive in one direction (Tetragonal and Hexagonal.)

Three systems simply refractive in two directions. (Orthorh. Monocl. and Tricl.

It has been pointed out by Brewster, Mitscherlich, Gmelin, Pereira and others that some crystals, when heated, expand equally in all directions, while in others the degree of expansion varies according to the direction, so that we obtain axes of greatest medium, and least expansibility. Careful recent experiments have confirmed this discovery of the earlier observers and we are now enabled to classify crystals according to their thermotic behavior, viz., the slight external changes brought about by various degrees of temperature.

Now it is certainly curious that the crystals which expand equally in all directions belong to the system in which the three axes are of uniform length, viz., the isometric. The crystals of two systems—tetragonal and hexagonal—expand equally in two directions, *which happens to coincide with their equal axes*, but those of the three remaining systems expand unequally in three directions. We have, therefore, once more the numbers 1, 2 and 3 in the following:

Thermic classification.

One system equally expanding in all directions. (Isometric.)

Two systems equally expanding in two directions. (Tetragonal and Hexagonal.)

Three systems unequally expanding in three directions. (Orthorh., Monocl. and Tricl.)

It has also been established that the conducting powers of crystals in reference to heat, sound and electricity are, in like manner, governed by their axial relations, so that we might produce additional classifications in which the numbers 1, 2, and 3 are exhibited in precisely the same way.

To sum up: The crystals of one system have three axes of equal length, are singly refractive and expand, on heating, equally in all directions. The crystals of two systems have two axes of equal length, are optically uniaxial and expand equally in two directions, viz., those of their equal axes. The crystals of three systems have all their axes unequal, are optically biaxial and expand unequally in three directions.

What are the conclusions which these facts enable us to draw with regard to the internal structure of crystals, the groupings, arrangement or shape of their ultimate particles?

Crystals, like all other aggregates, are composed of minute particles, and the difference between crystallized and amorphous matter may be likened to that between a well-drilled regiment and an unorganized mob. In crystals the component particles are symmetrically grouped or arranged, while in amorphous bodies they are piled up in a confused mass. More than 70 years ago the subtle Brewster[3] expressed his conviction that the optical properties of crystals "must depend on the form of their integrant molecules and the variation in their density" and it is astonishing how completely his views have been supported and confirmed by more recent speculations and research, or rather, what little progress has been made in this direction by our modern parlor scientists, who apparently attach more value to the discovery of a new mineral than to the solution of the great problems of crystallogenesis.

We will, for the sake of convenience, retain the commonly accepted term of molecules for the small particles, of which crystals are composed, and in considering the external forms of the latter, their optical, thermotic and other properties, we will endeavor to show in how far these physical phenomena can be accounted for by mere structural differences and modifications in the way of molecular grouping.

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[3] Philos. Transactions 1818, p.261.

There is no necessity that our particles should be primary in the sense of modern dynamics and chemistry, where an atom is defined as the smallest particle of an elementary substance which by mere juxtaposition with the particles of other substances give rise to a combination, and where the term "molecule" is applied to the smallest conceivable aggregate of atoms in a compound body.

An atom is, of course, practically invisible, and even the most complicated aggregate of atoms, as presented in the molecules of certain hydro-carbons, has hitherto escaped the resolving power of our best lenses. But the particles of which *Crystals* are composed can be clearly discerned with a $\frac{1}{10}$ inch objective—very rarely in the finished crystal, but whenever a substance is examined under the microscope during the process of crystallization—and wherever the operation of crystalline forces can be observed under high powers of magnification. There are grounds for believing that each of these visible particles (of which more anon) is an augmented molecule, viz., an *aggregate of molecules*, just as a molecule is an aggregate of atoms and that no single molecule is capable of manifesting polar forces of sufficient energy to enable it to play a part in crystalline economy.

In reference to primary molecules and atoms it is obvious that all observations on their shape and dimensions must remain speculative till opticians can furnish us with a combination of lenses which affords an amplification of at least 30,000 diameters. Considering the fact that no perceptible progress has been made during the last twenty-five years in the efficiency of high power objectives[1]—notwithstanding the periodical announcements of advertising opticians and their dupes, of pretended wonderful improvements—and considering the almost insurmountable difficulties encountered in this direction, the writer cannot but express his doubts whether the question of the size and shape of the primary molecules will ever be solved by direct observation.

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[1] The high-power objectives made twenty-five years ago by A. Ross, Wenham, Powell & Lealand, Richard Beck and others have not been surpassed and are barely equaled by those of the most renowned makers of the present. There has been absolutely no gain in amplification and the only apparent "progress" made is the very doubtful one that we can now, at extortionate prices, purchase objectives of wide angular aperture and comparatively low magnifying power. The use of wide angled high-power objectives is limited to a few objects, and in powers lower than a [illegible] great angular aperture is an unmitigated nuisance. To desire wide angular aperture in a "half-inch" objective is the hight of absurdity and it is to be regretted, in the interest of microscopy, that our opticians have been encouraged in the production of such monstrosities by a few addle-headed excentrics.

Two prevailing opinions, however, originated by the foremost observers of half a century ago, deserve our consideration. According to the deductions of Haüy, molecules and their constituent atoms are *angular* in form, while according to Wollaston, Hooke, Brewster and others they are more or less spherical. If we bear in mind the fact that all true crystals present angular outlines, which are persistently manifested even under the most adverse circumstances, and often strikingly repeated in their cleavage products, we may, at first, feel tempted to adopt the views of Haüy. What could be more natural and reasonable than the supposition that the fundamental form of a crystal is determined by that of its component particles: in other words that an octahedron of magnetite is an aggregate of innumerable minute octahedrons and a rhombohedron of Iceland spar built up of innumerable calcite rhombohedrons? There we have an hypothesis which accounts, in the most plausible and delightful manner for almost everything, except its own wonderful premises and these are, at once, its fatal stumbling block. The conception of a world composed of cubical, octahedral and dodecahedral molecules—not to mention the rest of holohedral forms of the six crystallographic systems—is, to say the least original, but a theory which, in order to explain one mystery, deliberately introduces another and far greater one, cannot be regarded as very satisfactory. This kind of philosophy reminds one of the Atharva-Veda tradition,in reference to the"foundations of the universe," expressed in stone on many a Hindoo temple. We there behold the figure of an elephant, carying on its back a huge disk, which represents the world. The elephant, again, is supported by a still more gigantic tortoise. The speculative Hindoo is not so much interested in the question of the world's creation as in the problem of its foundation or support. "What does the world rest on?" I once asked a Brahmin. "An elephant." And the elephant? "On a tortoise." And the tortoise? "Well—(after considerable hesitation) *that* supports itself." Indeed! supports itself. Would it not have been much simpler to make the world self-supporting at once? Why introduce the elephant and the tortoise? They explain nothing; on the contrary, they only increase the world's weight and our difficulty.

The "angular hypothesis" which maintains that the fundamental form of a crystal is determined by the shape of its integrant molecules, has very few adherents now, and is practically a thing of the past. On the other hand, the example of the spheroidal form of the planets, the tendency which liquids and even gases manifest to assume the spherical shape[5] and the mechanical facilities which the hypothesis of rounded particles offers in the grouping of molecules, have induced later inquirers to adopt almost unanimously the views of Wollaston and Hooke. We are now in a position to show, by circumstantial evidence—at least as weighty as that from which we infer the existence of a luminiferous ether—that molecules must be more or less spherical, and in the case of "augmented molecules" alluded to in the foregoing, viz., the minute particles of which crystals are composed, we have abundant direct proof of this, as their forms are revealed by a magnification of less than 1500 diameters.

But there is no reason whatever why the form of a molecule should not be capable of variation within certain limits. Why should it be absolutely constant? The conception of particles which under all circumstances preserve their outlines fixed and rigid is more difficult than that of particles which manifest a certain plasticity, and, with an elastic molecule as our starting point we can account for all the phenomena of crystallogenesis. It will be shown anon that this is more than an arbitrary hypothesis; molecules, when uninfluenced by external agencies, assume the spherical form, but pressure, whether exerted upon them by mechanical or polar forces, causes proportionate changes of outline. If once we can establish the precise character of these forces, we can, with comparative ease, determine the shape of each molecule in a given crystal. Symmetrical forms must necessarily result from forces equally exerted along particular lines or planes. If we compress a number of elastic rubber-balls, we observe that they assume oblong, hexagonal, cubical and even tetragonal forms, according to the character and direction of the energies employed.

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[5] Vide Pereira.

The planet, on which we live, is a spheroid, whose shortest diameter is at the same time its axis of rotation and the direction of greatest attraction. As far as we have been able to ascertain, the same conditions prevail on all the planetary bodies of our system. The analogy between planets and molecules is not a mere superficial one,[6] and reasoning from all the data in our possession, we cannot be far wrong if we look upon a free molecule as a rotating spheroid, with a north and south pole, and an equatorial region where gravity is, in some measure, counterbalanced by centrifugal force.

[To be continued.]

THE BRENHAM, KIOWA COUNTY, KANSAS, METEORITES

BY N. H. WINCHELL and JAMES A. DODGE, Minneapolis.

I

We are indebted to Prof. Robert Hay for information respecting the finding of this group of meteorites, and for assistance in procuring two of them. The entire group, so far as ascertained, numbered at least fifteen. They were discovered some years ago (1885) when the prairie of that part of the state was first plowed for cultivation, but the ranchmen and farmers simply regarded them with idle curiosity as "heavy stones." The high prairie and a sand-hill region, are totally destitute of stones of every kind. Only in the ravines is there a show of transported gravel. Some effort was made by some parties to attract the attention of scientists to them, but without success. Only lately has their true character been discovered. Several of them were at once purchased by Prof. F. W. Cragin, of Washburn College, Topeka, and by Prof. F. H. Snow of the Kansas State University, Lawrence. Two were purchased, at second hand, and are now at the University of Minnesota: four of the specimens of Prof. Cragin have subsequently been purchased by Mr. George F. Kunz, of New York, his collection weighing over nine hundred pounds. They vary in size from four pounds to four hundred and sixty-six pounds. The largest specimen is owned by Mr. Kunz, one of the smallest weighing six pounds, being one of those examined by the writers. They were scattered over an area of fifty or sixty acres, imbedded at shallow depths in the pleistocene upland.[1]

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[6] See the writer's paper on "Atomic worlds and their motions." Popular Science Monthly, December 1888.

According to Prof. Cragin they are closely allied in general characters, and belong to the class of *iron*, as distinguished from the *stony* meteorites, only one of them having a specific gravity above 7. The others seem to have been all fragments of one large pallasite of which the total weight, so far as discovered, was about 1,500 pounds. Three of these pieces have given a specific gravity between 5 and 6. Prof. Hay gives the specific gravity of our 6-lb. specimen at 5.17.

Before cutting, the larger of the specimens examined by us weighed 211 pounds. It was approximately globular, with a broad shallow depression that encircled it about half way. Its exterior is oxidized as by long exposure, some of the mineral grains having been profoundly affected by the penetration of iron oxide. Indeed the round or amygdaloidal masses of olivine (?) are changed so as to appear like some other mineral. In some cases this change has followed along a thin film, or between two outer planes of contiguous masses, coloring the included portion jet black and leaving the rest of the glassy, yellowish to white, brittle olivine (?) almost unaffected. After the mass was cut these two contrasted conditions of the olivine were so conspicuous that they were first taken for separate minerals. The external groove above mentioned coincides, superficially, with an area where metallic iron is absent. Other shallow depressions on the surface are due to the absence of iron. An irregular roughly triangular area is seen on the accompanying plate* projecting from the outer margin toward the centre, in which no metallic iron is visible. The mass was first cut twice through, giving a slab about an inch thick, and two plano-convex lenses. The smaller of the lenses was also cut into smaller samples, weighing from half a pound to two pounds each. The larger lens still weighs about 125 pounds. A photograph of the cut surface of the inch slab, reproduced in the accompanying plate, shows the manner of distribution of the metallic iron with respect to the other minerals, and its comparative amount.

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[1] The specimens, with their respective weights, so far as known by us are as follows: Owned by George F. Kunz, four, weighing 466, 345, 75 and 40 pounds; owned by N. H. Winchell, two, weighing 211 and 6 pounds; owned by F. H. Snow, one, weighing 54 pounds; owned by F. W. Cragin, one, weighing 125 pounds. The whereabouts of that weighing four pounds is not known, nor are the weights even of the remaining six specimens.

*The plate will accompany the second part of this paper.

Metallic iron comprises somewhat less than one-half of the entire surface, as cut, and it serves as a matrix in which are embraced amygdaloidal or roundish masses from the size of a pea to that of a musket-ball, and larger, of the black and yellowish minerals which comprise nearly the whole of the rest of the mass. The iron frame-work of the whole mass is not regularly cellular, but with many partings and tortuous shapes it fits closely about the concavities in which the minerals lie and gives firmness and shape to the whole.

The two most conspicuous minerals, or the two contrasted conditions of the same mineral, are readily distinguished at a glance, particularly on the fresh interior. When they are associated in a fragment from the rusted exterior they approach each other in general aspect, both being rusty brown. One is opaque black, with a shining, anthracitic lustre, and a brittle, angular non-laminate fracture. This lies near the iron more frequently than the other, and is most abundant about the edge of the slab, and in those areas where no metallic iron exists.

The other evident mineral, may be only the unoxidized and unstained condition of the foregoing. It has a light-yellowish color, or beeswax appearance. When broken it appears glassy and when crushed its powder is nearly white. It shows but rarely any cleavage direction but fractures irregularly and easily and even crumbles under pressure as if coarsely granular. Its hardness is about 6½, which is also that of the foregoing.

There is, moreover, much more sparse, another mineral. This is light brassy in color, and its hardness is not more than 4. It is also attractable by a magnet when powdered, and on being crushed its powder is black, or nearly black. Lining the cavities within the iron, and enclosing the other minerals, particularly when they consist of the brassy or the opaque-black mineral above is another black mineral. This gives the concavities within the iron matrix a botryoidal and specular reflection. Its hardness is about 3 or 3½, mashing down under a steel point somewhat like graphite, but it is, in fine powder lifted by the magnet. When unbroken and fresh it presents a silvery metallic lustre.

Some chemical examination has been made, but the final result of the analyses will be given in the next paper. In hydrochloric acid fragments of the dark mineral first mentioned afford gelatinous silica, and an odor of sulphur, the latter doubtless from some particles adherent from the other minerals. Chromium also is present, and a large amount of magnesia. The mineral approaches olivine or bronzite, and appears to be only a ferruginated condition of the glassy-yellow mineral.

In thin section the yellowish mineral is transparent. It presents the roughened surface seen on thin sections of olivine, but it has not its brilliant polarization, in the latter respect resembling bronzite. It is intersected irregularly by fissures in which is gathered a ferruginous product of decomposition (limonite), and which increase to so great an extent that in some places, the section is nearly opaque, showing a gradation from the black-opaque mineral mentioned to this yellowish glassy one, and indicating their original identity.

Besides these transparent polarizing minerals there may be seen two that are always and entirely opaque. One is black as above, and may be the one that contains the chromium already detected, but the other is brassy. The former may be chromite or daubréelite and the latter troilite.

[To be continued.]

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Report of the School of Mines of Colorado, 8vo pp. 264. We have received from Prof. ARTHUR LAKES, state geologist of Colorado and one of the editors of the AMERICAN GEOLOGIST, a copy of his annual report for 1889 containing a narrative of the exploration of the coal deposits of that state during the preceding year. It opens with a chapter on the natural history of coal in which the author points out that though the coal supply of Colorado is not of Carboniferous but of Cretaceous age and consequently much younger than that of the eastern states, yet it is of good quality. This is not, he says, generally believed. "We have anthracite as good as that of Pennsylvania, bituminous coals in beds of great thickness comparing favorably with that of the east and of such remarkable purity that it will yield coke as good as that of the far famed Connellsville field." "If the western states had been discovered first and had become as thickly populated as the eastern states now are, it is a question whether Colorado, Wyoming and adjacent territories would not have been considered the great coal-area of the U. S."

On the resources of the far West he says: "At least 20,000 sq. miles of Colorado are underlaid with coal. Texas has 30,000 sq. miles, Dakota 100,000 sq. miles. New Mexico has at least 600,000 acres of coal, ranging from anthracite to lignite, Wyoming 20,000 sq. miles, Montana 20,000 sq. miles."

Judging from the analyses, many of which are given in the volume, most of these coals are of good quality,standing low in moisture and in sulphur and not excessively high in ash. Doubtless only the best seams and the best parts of them will at present pay for working. Prof. Lakes points out that the anthracite though of good quality is not known to be sufficient in quantity to make it a factor of importance in the resources of the State.

The volume is well illustrated with fifteen outline views which aid largely in enabling the reader to follow and understand the nature of the country and its geology.

The Evolution of Climate. By James Geikie, LL.D., F.R.S. pp. 22; with maps. (Reprinted from the Scottish Geographical Magazine for Feb. 1890.) This paper will be of much interest and value to students of palæontology and of structural and glacial geology. It is accompanied by two plates, the first of which shows four small sketch-maps illustrating the geographical evolution of continental areas, and the second is a geological map of the world by J. G. Bartholomew.

The early origin and permanence of the continental plateaus and oceanic basins is maintained, as taught by Dana; but during Archæan, Palæozoic and Mesozoic time the present extensive land areas were probably represented by islands, between which shallow expanses of sea permitted marine currents to carry warmth from the tropics to the circumpolar regions. These conditions produced very remarkable uniformity of climate, and consequent close relationship of the fauna and flora, over the whole globe. In the Cainozoic era the extent of the land increased, causing the sea to retreat from hitherto submerged parts of the continental plateaus; and the land-growth was attended by a gradual lowering of the temperature of northern and temperate latitudes and the differentiation of climate into zones.

We now come to the principal purpose of this paper, which is a defense of Dr. Croll's theory of the causes of the ice-age. Professor Geikie believes, with Wallace, that extensive ice-sheets, like those of the Quaternary glacial period, could not be formed in earlier eras because the influence of recurring epochs of maximum eccentricity of the earth's orbit was then mainly counteracted by the geographical conditions, with a possible exception in the Permian period. His adherence to this astronomic theory seems not to have taken account of recent investigations by geologists in this country, who are led to measurements of postglacial time, from the recession of the falls of Niagara and Saint Anthony, and from the rate of wave-erosion on lake Michigan and the resulting formation of deposits of beach sand and dunes, which show that the departure of the ice-sheet of the last glacial epoch in the northern United States was only some 7,000 to

10,000 years ago. The Ice age here appears to have been subsequent to the last period of eccentricity, and was probably due to great elevation of the area glaciated, giving it a cold climate; but this might be most efficient for the accumulation of ice-sheets, in accordance with Dr. Croll's argument, when winter of our northern hemisphere was in aphelion, which coincided with the date thus indicated for the latest glaciation of this continent. On the other hand, the return of warmth and departure of the ice were coincident with subsidence of the glaciated portions of the earth's crust, which indeed appears to have been due to the weight of the ice and to have become in turn the principal influence leading to amelioration of climate and the final glacial melting.

Mammilian Remains from the Southern States; by PROF. JOSEPH LEIDY. With the exception of a short article by Edward Potts on fresh-water sponges, volume II of The Transactions of the Wagner Free Institute of Science (Phila.) is composed exclusively of six interesting papers on fossil vertebrates from Florida, Louisiana and elsewhere as follows:

1. *Notice of some human bones.*

2. *Description of mammalian remains from a Rock-Crevice in Florida.* These fossils are from Ocala, and consist of species of the horse, llama, tiger, and elephant. The most interesting is the sabre-toothed tiger, which, according to Dr. Leidy, differs materially from *Machairodus neogæus* and he proposes the name *M. floridanus.*

3. *Description of Vertebrate Remains from Peace creek.* The animals recognized by Dr. Leidy are *Tapirus americanus* (molars), *Equus* (molars, incisors), *Hippotherium* about the size of *H. ingenuum*, *Bison americanus* (molar, phalanx), *Cervus virginianum* (antlers, bone, teeth), *Elephas columbi* Fal. (teeth). "Perhaps the most interesting of these fossils are a number of dermal plates of Glyptodonts." Some of the plates belong to *Chlamydotherium humboldtii* Lund, others to *Hoplophorus euphractus* Lund, *Megalonyx jeffersoni* (1st. phalanx), *Manatus antiquus* (ribs), six vertebræ and teeth of an undetermined cetacean, fragments of *Emys euglypha* and *Trionyx*, some remains of a huge tortoise and a distinct specimen named *Testudo crassisculata*, teeth, plates and mandible of *Alligator mississippiensis* and some remains of fishes.

4. *Notice of some Mammalian remains from the Petite Anse salt mine La.* describing *Mastodon americanus*, *Equus major* and *Mylodon.*.

5. *On Platygonus, an extinct genus allied to the peccaries.*

6. *Nature of Organic Species*, in which Dr. Leidy gives a short study in the evolution of forms by a treatment of the extinct and living forms of *Fulgur*, showing the fossil *F. contrarius* continuing to the present in the living form *F. perversus.* These articles are well and carefully illustrated by ten good plates.

Eighth Annual Report of U. S. Geological Survey. 1061 pages in two parts. Part I contains, besides the usual administrative reports, financial condition, etc., the following papers: The Quaternary History of Mono valley, Cal., by I. C. Russell; The Geology of the Lassen Peak District, by J. S. Diller; The Fossil Butterflies of Florissant by S. H. Scudder. Part II contains an exhaustive monograph of 157 pages on The Trenton Limestone as a Source of Petroleum and Natural Gas by Edward Orton; an important addition to palæobotany, The Geographical Distribution of Fossil Plants (300 pages) by Lester F. Ward; A Summary of the Geology of the Quicksilver Deposits of the Pacific slope, by George F. Becker, and The Geology of the Island of Mt. Desert, Me., by N. S. Shaler.

The Potomac or Younger Mesozoic Flora, by W. M. Fontaine. Monograph No. XV, U. S. Geological Survey. Part I, text 337 pp. Part II, 180 pl. The greater number of species described in this monograph are new and important. Of the cryptogams there are three new genera and 137 new species. Of the phanerogams two new genera and 17 new species, of gymnosperms seven genera and 89 species of conifers. Among the angiosperms 19 new genera and 72 new species.

CORRESPONDENCE.

The Genus Terebellum in American Tertiaries.—While looking over some material in the collection of the United States National Museum from the Eocene formation of Texas,[1] several beautiful and well preserved casts of a small *Terebellum* were observed. This the writer believes to be the first time the genus has been noted in the Tertiary formation of this country. The species mentioned under this genus by Tuomey and Holmes from the Pliocene of South Carolina[2] belong properly to *Turritella* as the term is ordinarily used. The Texas forms are somewhat elongate, and, when studied more carefully, will perhaps be found to belong to the section, *Terebellopsis*, Leymerie.

U. S. Geological Survey, April 3, 1890. Gilbert D. Harris.

The American Neocomian and the Gryphæa Pitcheri—"A preliminary annotated check list of the Cretaceous invertebrate fossils of Texas," by Robert T. Hill, Geological survey of Texas, Bulletin No. 4, Austin, 1889, is too important a paper not to point out a few incorrect statements, which, very likely, have escaped professor Hill's attention in the haste of preparation, such a work being always attended by great difficulties as to exact references and the right of priority.

We read at p. VII: "It is now known that the series of rocks which a few years ago were considered as the whole Cretaceous group of the United States, east of the Rocky mountains, on the section published

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[1] Station No. 2056, Eocene, Mt. Enterprise, in the southeastern part of Rush county, Texas, L. C. Johnson, U. S. Geol. Sur., Collection.

[2] *Terebellum striatum* T. & H., *T. exaltatum* Con., *T. etiwanensis* T. & H., *T. burdenii* T. & H. "Fossils of South Carolina, Pliocene and Post-Pliocene," Tuomey and Holmes, 1855-60, p. 120-122, pl. 26, figs. 7-11.

Forty-second annual report of the trustees of the state museum of natural history for 1888, Albany, pp. 496, 8vo.

(1) The Archeology of the Potomac tide water region. O. T. Mason.

(2) The paleolithic period in the district of Columbia, from the proceedings of the U. S. Nat. Mus. vol, XII, pp 367-376.

Preliminary report on the collection of mollusca and brachiopoda obtained in 1887-88 (U. S. Fish Commission). W. H. Dall, from the Proc. U. S. Nat. Mus., vol. XII, pp. 219-362, plates V-XIV.

The collection of building and ornamental stones in the U. S. Nat. Mus.; a hand-book and catalogue. Geo. P. Merrill, Smithsonian report, 1885-86. Part II, pp. 277-648, pls. I-IX.

Fossil wood and lignite of the Potomac formation, F. H. Knowlton, Bul. No. 56, U. S. Geol. Survey, 1889.

2. *Proceedings of Scientific Societies.*

Observations on the Eocene Tertiary and its Cretaceous associates in the state of Maryland. P. R. Uhler. Trans. Maryland Acad. Sciences, in 1888 and 1889.

The pre-Cambrian rocks of the Black Hills, C. R. Van Hise. Bul. Geol. Soc. of America. Vol. I, pp. 203-244, 1890.

Proceed. Iowa Acad. Sciences, for 1887, 1888 and 1889, contains: The terraces of the Missouri (abstract), J. E. Todd; The origin of the extra-morainic till (abstract), J. E. Todd; Directive coloration in animals (abstract) J. E. Todd; On a new fossil Limnæid from the Post-Pliocene of California (abstract; printed in full in the AMERICAN GEOLOGIST, vol. I, Mar., 1888), R. Ellsworth Call; Some additional observations on the loess in and about Muscatine, (abstract), F. M. Witter; The Geology of Crowley's ridge, Ark. (abstract), R. E. Call; The lineage of lake Agassiz (abstract), J. E. Todd; On the folding of the Carboniferous strata in southwestern Iowa (abstract), J. E. Todd; The crystalline rocks of Missouri (abstract) Erasmus Haworth; On the Geology of eastern Arkansas (abstract), R. Ellsworth Call; Notes on a fossil wood from the Keokuk limestone (abstract), C. H. Gordon; On the Keokuk beds and their contained fossils, (abstract), C. H. Gordon; Observations on the Keokuk species of Agaracocrinus (abstract), C.H. Gordon.

PERSONAL AND SCIENTIFIC NEWS.

COAL IN THE SOUTH OF ENGLAND. For many years the opinion has been held by some of the leading geologists of England that coal exists below the mesozoic rocks that cover the surface of the southwest counties. Several attempts have been made at different times to reach this supposed store of fuel but without success, though every boring confirmed the belief that the Carboniferous rocks underlie that part of the island. On February 17th a communication of the discovery of coal was made to Sir Edward Watkin and if the hopes of the drillers are confirmed and maintained an important epoch in the history of coal mining in England will be marked. It is stated that coal has been found at the depth of 1180 feet under conditions that favor the belief that it will pay for working. Writing on the topic professor Boyd Dawkins who has always advocated the exploration says: "The Coal Measures with good blazing coal have been struck at a depth well within the practicable mining limit and the question is definitely settled which has vexed geologists for the last thirty years. Further exploration however, now under consideration, will be necessary before the thickness of the coal and the number of seams can be ascertained."

Whatever the commercial result may be, this discovery is a gratifying instance of correct reasoning from geological data. The contention has been that the palæozoic rocks, which in the west carry the coal beds and which show an anticlinal structure running east and west pass under the London and Paris basin and reappear in the Belgian coal-fields near Liége. Consequently it was inferred that they could be found in the intervening area at no excessive depth. Several borings have shown the truth of this argument, but though palæozoic rocks were found no coal-bed has been struck until this late successful attempt. Should the find prove economically valuable it will be a singular instance of the return of an industry to its former situation, as in the days of charcoal furnaces much iron was smelted in Sussex and other southern counties. It is said that the railings round the dome of St. Paul's cathedral were cast there. With the introduction of coal and coke, however, the manufacture migrated to the north.

The General Committee constitued to make arrangements for the session of the International Congress of Geologists at Philadelphia, in 1891, held its third meeting in the National Museum at Washington, on April 18, 1890. There were present chairman Newberry, secretary H. S. Williams, and Cope, Dutton, Frazer, Gilbert, Hague, Hall, Lesley, Marsh, Powell, Stevenson Walcott and A. Winchell. The committee adopted resolutions to the following effect:

1. That the local committee previously appointed for Philadelphia be discharged. Moved by Prof. Lesley.
2. That it is the sense of the General Committee that no postponement of the session is desirable; but that it should be held, as appointed in 1891.
3. That it is the sense of this committee that the session should be held in Washington instead of Philadelphia.
4. That the secretary be instructed to transmit this action to the Bureau in London.

The determinations of the General Committee were based on the obvious impossibility of insuring desirable success under the arrangements existing for holding the session in Philadelphia. An effort was made to provide for appending the "ayes" and "nays" on the question of recommending removal, but this failed. Such information, nevertheless, would certainly have been useful to the Bureau as showing the weight of sentiment in favor of removal, and showing also that Dr. Frazer who had been so largely instrumental in pressing the invitation from Philadelphia did not entertain the conviction that a change of location was necessary.

Finally, the chairman was instructed to inform provost Pepper of the University of Pennsylvania, of the action of the committee and explain in language courteous and conciliatory as possible, the fact that the change of location had been recommended, simply because the committee had been convinced that it is now impracticable to insure success in a session held in Philadelphia.

The hope, nevertheless, is privately expressed that, with more time for reflection and inquiry, it may yet appear possible to meet in Philadelphia in 1891 and accomplish a success creditable to American geology.

THE ELECTION OF PROF. F. H. SNOW TO THE CHANCELLORSHIP of the Kansas State University (Lawrence) has rendered it desirable that some one shall aid him in the work of the department of geology and natural history; and the regents recently elected Prof. S. W. Williston, of Yale, associate professor of geology and palæontology. Prof. Williston, who is a graduate of Kansas Agricultural College, has more recently been assistant to Prof. O. C. Marsh.

THE SCIENTIFIC PUBLISHING COMPANY, NEW YORK, announce the publication of "Gems and precious stones of North America," by George F. Kunz. The professional standing of the author will serve as a guarantee for the excellence of the work. The volume is to be handsomely illustrated by colored plates by Prang & Co., Boston. Roy. octavo. Price $10.00.

THE SUMMER SCHOOL OF GEOLOGY of Harvard University will carry on an advanced course in geological field-work in eastern New York and southern New England, under the direction of Profs. Shaler and Davis, assisted by Prof. H. S. Williams, Dr. J. E. Wolff and Dr. W. B. Clark.

STUDENTS OF PALEONTOLOGY WILL HEAR WITH MUCH REGRET of the recent death of Prof. von Quenstedt, of Tübingen. He was a leader among German palæontologists, and did much important work in mineralogy also. He had an especially profound knowledge of the Lias of Würtenberg and its fossils. His work on "Der Jura" is well known, and so recently as 1885 a new edition, greatly modified, of his "Handbuch der Petrefactenkunde" was issued. Dr. von Quenstedt died at an advanced age on December 21st, 1889.

DR. RICHARD OWEN, WELL KNOWN TO GEOLOGISTS for his "Reconnoissance of the state of Indiana," and other contributions, died recently at New Harmony, Ind. In a future number of the GEOLOGIST there will be a sketch of his life and scientific work.

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A GEOLOGICAL SURVEY OF THE CONCHO COUNTRY, STATE OF TEXAS.

By PROFESSOR W. F. CUMMINS AND DR. OTTO LERCH.

The country takes its name from the rivers traversing it. About twenty years ago it was the hunting ground of the Lepan Indians, Kickapoos, Comanches and Kiowas. In 1868 the U. S. Government erected a post on the banks of the North Concho river which became the nucleus of the settlement and the prosperity of this country. It soon became noted to the stockmen for its many varieties of nutritious grasses and its abundance of water. Settlement advanced so rapidly that on the 13th of March, 1874, a new county was organized containing 13,000 square miles, which was called Tom Green, in honor of the famous general of the confederacy, a son and citizen of the State of Texas. This county was situated west of the 100 meridian, between 31st and 32nd parallels of north latitude, east of the Pecos and south of the Colorado rivers. Recent Legislatures have divided this vast area into six new counties. The eastern half of old Tom Green county, embracing the new counties of Arion, Coke and Tom Green, is now generally known as "The Concho Country," and is the subject of the following report. In less than twenty years this country has passed through the different stages of human civilization; the stockman has succeeded the hunter, and the farmer is succeeding the stockman.

San Angelo, the county seat of Tom Green county, has been built at the confluence of the Concho rivers, and contains at the present about 4,000 inhabitants. Its site has been very happily chosen. It lies in the beautiful and fertile valley of the Main Concho river, which at this place is not less than thirty miles in width. Blue ridges of Cretaceous hills bound the valley on the north and south, and the waters of the Main Concho river traverse it. This is the only town of any considerable size west of Ft. Worth and Dallas, and of great commercial importance for western Texas. It is the largest shipping point in the state for stock. A prominent wool market and its trade extends over hundreds of miles north, south, west, and east. It has very handsome public buildings, large commercial stores, banks, waterworks, ice factories, good weekly papers, and is connected by the G. C. & S. Fe R'y with the east.

Drainage and Topography.

The North Concho river traverses the country diagonally from northwest to southeast. The Main Concho river from west to east, Spring creek and Dove creek from southwest to northeast, and the South Concho river from south to north. The Colorado river having a southeasterly course, drains, with its tributaries, the north-eastern portion of this country. The above mentioned rivers and creeks have an abundance of running water during the entire year, and many of their tributaries not here mentioned are perennial streams. The rivers and creeks have their sources on the Staked plains and flow with an average fall of ten feet per mile.

TWIN MOUNTAIN.
From the Knickerbocker Road.

a. Permian. b. Cretacic.

Considering this, a glance at the accompanying map will show that the country is well drained. The topography of the section is easily understood, if considered in connection with its geological features. It constitutes a part of the Cretacic deposits known as the Gulf series. These deposits have been laid down by the Cretacic sea till a gradual elevation of the strata took place and the retreating waters left the former bottom of the ocean a part of the continent, a vast undulating plain. Concluding from the fact that these deposits are only covered by alluvium, no new subsidence has taken place in this country, but the waters retreating have commenced to cut their channels and have so well succeeded that they have cut through the whole Cretacic series, and in their lower courses into the underlying Permian formation. The valleys are narrow at the beginning, gradually widening and deepening till at their confluence, they form a valley not less than 30 miles in width.

Plateaus, remnants of the former plain with gentle declivities, changing frequently to abrupt escarpments of picturesque appearance, lie between rivers and creeks.

Geology.

The geology of this country is the more interesting as three grand periods of our world's history are represented in the circumference of a few miles. The Permian formation, the transition period between the old and new forms of life, underlies the Cretacic, the last of Mesozoic time, which represents in its wide plains the accumulations of the Cretacic ocean. In these, diluvial floods have left their traces; deep and wide valleys, narrow cañons, steep embankments, hills, ridges and huge deposits of conglomerate speaking of the dawn of a recent period, and marking the prominent features of the present topography of this portion of Texas. Quiet waters succeeded, left in basins and hollows by the retreating diluvial floods. The valleys had then a swampy appearance, covered with small lakes and lagoons in which modern life commenced to flourish, and through which the rivers wind their way, grinding the rocky material and transporting and depositing the fine sediment which at the present marks their courses, and is recognized by the geologist as loess deposits. It was left to alluvial times to drain gradually these many swamps and lakes, to form the variety of soils, to cover valley and plain with a dense turf of nutritious grasses, and people them with buffalo, antelope and Indians. Modern times have commenced to work out another change, the white man has replaced the Indian, cattle the buffalo and antelope; and the cultivation of the soil, roads and railroads and works of irrigation are changing daily its surface features.

Recent Geology.

Alluvium.—The river bottoms or valley lands, formed in recent periods through rains and wind, frost and sunshine, with the powerful aid of carbonic acid contained in the atmosphere, are derived from the underlying Cretacic and Permian strata. These are in thickness from 20 to 30 feet, in some places interstratified with loose gravelly deposits. The uplands are covered with alluvial soils generally from two to fiye feet thick.

Drift.—Beds of hard limestone conglomerate situated along the rivers and creeks are often 50 to 60 feet thick. They are purely local, as is evinced by the large size of the boulders, and from the fact that they are of limestone from the surrounding strata. Frequently the boulders are but little waterworn, evidently having been rolled but a short distance. We have been unable to determine with certainty the age of these deposits, as no fossils have been found *in situ.* Yet it is most probable that an inland sea covered the Staked Plains, till in diluvial times an elevation of the western side of the continent took place, and the waters of this vast sea commenced flowing toward the gulf, leaving the valleys and these beds as evidence of their action.

Lacustrine Deposits.—Succeeding the drift epoch are deposits of an ash-gray or brownish color containing sand and clay, and generally spotted with small white calcareous concretions. They have been deposited by quiet waters in basins forming lakes and lagoons. They are sometimes found 30 feet thick, generally overlying or leaning on the drift. No fossils have as yet been found in the loess of this country. The deposits of this material have been made in basins of comparatively small size along the river channels, their size depending on the general width of the valley. The rivers in cutting their way through them have left these deposits exposed in steep bluffs and embankments. The composition is a calcareous sandy loam of a light yellowish brown color, very porous, with a number of calcareous incrustations. The material is unstratified.

The Cretacic—Preceding the drift, covers the larger part of the Concho country. It rests unconformably on the Permian.

and dips from northwest to southeast about 30 feet to the mile. It is easily recognized even from a distance, standing out in conical hills with flat tops and gently rounded ridges, sometimes with bold escarpments of an amphitheatre-like appearance. The surface of the wider plateaus lying between rivers and creeks, falls slightly toward the southeast, following the general dip of these strata. Their borders are broken by ravines, leaving the above mentioned hills and ridges. Frequent and continued washings have covered the bases of the hills with detritus, making gentle declivities, covered with a spare vegetation of grasses and mesquite brush. Along the hillside the deposits are well exposed, facilitating the study of their dip, strike and composition. They vary from a few inches to many feet in thickness, with slight changes in the same horizon. The Cretacic has been conformably deposited in this country, but the different changes of level of this group are well defined by difference of composition, density and color. The cleavage of the rocks is horizontal, along the strata, but frequently the rocks appear vertically cracked, the cause of which is pressure of over-lying rocks, moisture and frost. The material of this Cretacic group changes from hard blue limestone often semi-crystalline, passing through different stages of density and color, to pure, white, soft stone; sometimes it is argillaceous, sometimes arenaceous, changing in color from a yellowish brown to a dirty brown or red. A peculiar brecciated limestone we have found interstratifying these layers near the top of this group. It is composed of hard limestone pebbles of a blue-grayish color, embedded in a calcareous brown yellowish matrix, which when exposed is easily washed out, leaving the ilmestone pebbles in their former condition. These exposed strata are then called by the people "honeycomb rock" from their peculiar appearance. Overlying this rock is a dense yellowish colored limestone, indicating the change from a shallow beach to the deep sea. According to the sections examined there is sand or loose sandstone at the foot of this Cretacic group which is so generally found in other countries constituting the lowest member of this period. No violent action has disturbed the almost horizontally deposited Cretacic strata in this country, but a gradual rise, the lifting force working vertically to the dip, has placed the deposits beyond reach of the waves and has sent the water to the gulf. The thickness of the whole of the Cretacic group in this country called Comanche series by R. T. Hill has been estimated by us from the different sections examined to be 400 feet.

SECTIONS ON SOUTH CONCHO, 20 MILES SOUTH OF SAN ANGELO.

1. Hard buff colored limestone, layers several feet thick......30 ft.
2. Yellow clay with Exogyra texana..........................30 ft.
3. White shaly sandstone....................................40 ft.

LIST OF FOSSILS.

1. *Gryphæa pitcheri.*
2. *Exogyra texana*
3. *Ammonite*——— ?
4. *Lima wacoensis.*
5. *Trigonia texana.*
6. *Nautilus.*
7. *Nerinea texana.*
8. *Ostrea*——— ?

The Permian.—This formation in this country conformably overlies the Carbonic, dipping from southeast to northwest, about 30 feet to the mile and is overlain unconformably by the Cretacic deposits. The change from the Carbonic to the Permian is gradual. The Carbonic forms of life mingling with newer types, gradually disappear more and more, giving place to the new forms, until in the upper strata of this epoch they appear in such abundance, and leading Carbonic forms are so rare, that noted explorers have termed it Triassic. The clay beds of the Carbonic formations gradually lose their black color and appear now variously colored, deep venetian red, blue and yellow, passing frequently through all the different shades. The limestone interstratifying the different Carbonic deposits has changed and has become an argillaceous and arenaceous rock of yellowish brown and red color, frequently passing into pure sandstone of different colors, white, yellow, and sometimes of a deep red. The formation is exposed above and below the confluence of the Concho rivers, and along the Colorado river. Sandstone and limestone deposits of various thicknesses according to sections examined from one foot to six feet, are interstratified by clay deposits from a few feet to forty or more in thickness. The clay is massive or shaly, and the limestone and sandstone are of different densities, argillaceous and ferruginous. The fossils are generally fairly well preserved in an argillaceous limestone of drab color, but difficult to obtain on account of the hardness of the rocks. Along the Colorado river the gypsum beds appear lying conformably upon the older strata of this period, forming the highest member of this formation. The Permian deposits in this section belong to the southern edge of this formation in Texas. Their thickness has been estimated by us from borings and outcrops examined, to be 200 feet. No volcanic action has disturbed the Permian strata in this country. Their composition speaks of shallow water beaches and quiet muddy seas accompanied by frequent oscillations of the sea bottom. We have been able to obtain only marine fossils and cannot say therefore with certainty that portions of this country had been raised above the waves of the sea in this period. The change from the Permian to the Cretacic is abrupt. The earlier members of Mesozoic time, the Triassic and Jurassic, are missing, and it must be concluded that either these formations had never been deposited in this section or that after being laid down they were destroyed by subsequent erosion. The Cretacic commences with a loose sandstone in the lower strata, gradually changing to pure, hard limestone.

SECTION OF THE PERMIAN.

1.	Sandstone	4 feet.
2.	Yellow Sandstone, friable	2 "
3.	Sandstone, shaly	40 "
4.	Red Clay	20 "
5.	Limestone, Fossiliferous	3 "
6.	Green Clay	8 "
7.	Red Clay	6 "
8.	Green Clay	2 "
9.	Limestone	18 in.
10.	Whitish Clay	1 foot.
11.	Limestone	1 "
12.	Whitish	1 "
13.	Blue Clay	3 feet.
14.	Limestone	8 in.

LIST OF FOSSILS.

1. *Goniatites baylorensis* White.
2. *Medlicottia copei* White.
3. *Orthoceras rushensis* McChesney.
4. *Nautilus winslowi* Meek and Worthen.
5. *Euomphalus subquadratus* Meek and Worthen.
6. *Bellerophon crassus* Meek and Worthen.
7. *Pleurophorus* ——— ?
8. *Myalina permiana* Swallow.
9. *Aviculopecten*——— ?
10. *Productus* ——— ?
11. *Murchisonia* —— —— ?
12. *Fenestella* —— —— ?

Economic Geology.

Climate.—Conditions of the air, rainfall, soils and water. On account of the high altitude of this country, 2000 feet above the level of the sea, the pressure of the air considerably lessens, and in consequence respiration is quickened and evaporation increased. As a curative agent the air of elevated places has been highly recommended in cases of phthisis, malaria, digestive troubles, etc.

Movement of the Air.—This is a very important climatic condition. The wind has a cooling effect on the body and if dry increases the evaporation. Though the average temperature during the month of January (the month of the north wind in Texas) is 40° F., a temperature, which in a quiet at-

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1886	N.	4	3	3	1	2	,,	,,	2	3	7	8	11
	NE,	2	1	4	,,	5	3	4	1	1	2	6	6
	E.	5	2	5	,,	1	2	1	5	2	1	1	1
	SE.	1	3	1	4	6	6	5	6	4	4	,,	1
	S.	5	4	9	11	10	15	7	11	12	6	4	1
	SW,	6	5	6	6	7	4	6	5	3	1	6	4
	W.	3	1	,,	5	,,	,,	5	1	1	5	3	3
	NW	2	4	3	3	,,	,,	3	,,	4	5	1	4
1887	N.	5	4	2	"	2	1	3	4	6	5	8	9
	NE.	3	1	1	3	1	2	1	4	2	2	5	5
	E.	1	5	4	4	3	1	2	1	,,	,,	1	,,
	SE.	6	4	5	1	4	3	4	5	,,	3	3	1
	S.	7	1	6	7	14	11	10	6	9	8	3	1
	SW,	1	7	1	5	2	4	5	7	5	3	1	4
	W.	6	1	7	6	1	7	1	4	1	4	5	6
	NW	2	3	5	4	4	1	5	,,	7	6	4	5
1888	N.	3	2	6	1	4	7	1	6	5	2	6	8
	NE.	6	3	,,	,,	1	3	1	4	3	5	1	6
	E.	1	4	2	,,	1	,,	3	1	1	6	5	1
	SE.	2	4	3	6	3	,,	5	3	7	1	4	3
	S.	3	1	9	17	10	11	9	4	7	6	3	2
	SW,	9	5	4	4	5	5	6	5	1	7	6	4
	W.	4	6	1	2	,,	1	5	4	7	2	4	4
	NW	3	4	6	1	7	3	1	6	.	4	1	3
1889	N.	3	1	7	3	2							
	NE.	5	2	.	4	1							
	E.	1	5	5	1	4							
	SE.	4	3	1	1	7							
	S.	5	3	8	10	16							
	SW,	6	4	1	8	.							
	W.	1	8	7	1	.							
	NW	6	2	2	2	1							

mosphere would be not uncomfortably felt on account of the increase of evaporation, and the change of the air enclosing the

TABLE SHOWING THE AVERAGE TEMPERATURE TOGETHER WITH THE HIGHEST AND LOWEST POINTS RECORDED DURING EACH MONTH SINCE APRIL 1868, AT FT. CONCHO,

SAN ANGELO, TEXAS.

YEAR.	January.			Febru'y.			March.			April.			May.			June.			July.			August.			Septemb'r			October.			November			December		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
1868										98	36	67.20	101	55	80.03	107	57	84.11	112	65	87.58	111	64	88.10	107	49	79.12	96	40	66.31	87	32	58.30	90	24	47.71
'69	75	21	45.93	85	28	50.17	96	33	57.46	92	36	63.98	101	45	79.37	98	55	76.55	100	65	74.53	108	70	83.26	110	43	71.87	102	32	57.68	102	28	50.68	84	12	48.96
'70	84	19	41.70	71	19	49.83	89	25	55.84	90	35	65.17	98	59	72.82	98	63	78.06	100	63	80.90	101	70	81.12	98	61	75.87	96	43	68.80	98	27	49.62	80	7	41.04
'71	78	12	44.58	95	27	53.57	95	35	59.08	101	32	69.04	102	43	73.12	102	66	82.41	102	72	87.19	102	68	81.85	90	50	74.85	90	38	65.47	81	23	51.84	80	13	44.72
'72	79	13	40.98	81	22	49.60	87	30	54.74	90	37	61.98	102	42	71.56	102	58	78.00	100	65	82.75	102	60	85.25	102	49	78.43	97	33	65.69	82	19	52.01	80	20	42.15
'73	80	2	45.00	82	18	54.24	86	30	61.47	94	31	63.83	99	44	73.50	100	66	81.50	102	64	86.85	102	60	83.09	107	50	81.60	100	34	70.00	86	31	57.02	73	31	48.85
'74	80	18	46.50	82	28	53.50	84	35	57.39	91	34	64.67	99	57	79.92	104	72	87.62	108	73	88.42	108	70	84.31	103	50	75.96	96	40	67.70	97	27	60.01	76	28	48.50
'75	71	0	37.43	78	4	43.63	92	28	67.76	95	47	69.06	107	51	77.10	105	56	81.18	104	59	80.31	104	53	81.87	100	48	76.87	96	41	69.12	92	23	58.46	80	28	52.78
'76	70	31	51.16	85	19	52.44	86	19	54.24	98	34	69.26	101	45	76.35	104	56	84.20	110	63	84.33	113	66	83.35	101	48	76.10	91	42	68.61	82	29	50.80	74	9	39.[illegible]
'77	78	14	45.64	87	24	53.18	84	20	61.84	89	35	63.70	97	42	72.91	101	50	80.17	104	56	84.43	103	63	83.18	100	49	77.50	98	30	66.97	77	15	49.90	71	15	47.55
'78	74	8	43.62	84	10	49.74	88	29	57.71	98	40	67.18	96	43	73.26	102	58	80.50	100	50	82.89	99	56	83.90	91	41	72.94	93	27	66.82	83	15	54.88	71	8	39.[illegible]
'79	76	3	46.28	87	11	49.35	92	19	63.76	91	31	66.31	101	50	78.95	102	48	82.72	107	66	88.79	101	57	79.44	101	51	75.11	91	32	68.69	87	15	57.47	84	0	49.86
'80	88	15	57.23	66	15	50.21	86	14	58.52	97	25	71.49	98	46	78.61	101	52	82.34	101	55	84.09	96	47	78.91	98	44	71.85	88	32	64.78	78	8	43.28	82	2	34.06
'81	82	6	37.96	78	16	47.58	86	26	58.32	96	32	66.84	90	48	73.17	106	59	84.81	106	65	86.65	101	61	86.13	98	58	80.52	90	40	71.19	86	32	58.04	76	21	51.13
'82	71	18	46.51	77	31	55.71	88	28	61.90	95	30	68.16	94	52	71.08	103	57	81.88	109	65	83.89	97	58	78.46	90	47	72.51	88	42	69.26	88	25	56.60	78	17	44.31
'83	78	3	41.87	81	5	45.90	84	26	57.41	94	31	62.98	103	48	77.35	105	54	83.61	102	65	84.23	104	58	80.48	98	43	73.10	96	35	66.83	87	10	52.76	82	0	47.28
'84	7[illegible]	5	38.04	82	17	46.85	89	26	58.97	95	32	61.56	93	44	69.82	100	53	78.14	110	68	82.76	103	73	84.05	101	63	81.68	95	42	62.37	80	20	55.69	82	10	46.98
'85	74	[illegible]	39.35	79	15	45.64	90	30	54.61	93	12	67.18	93	45	71.09	107	62	82.05	103	65	83.44	105	62	84.28	96	63	77.33	94	36	61.89	88	25	56.84	75	15	51.10
'86	80	3	39.51	78	17	50.15	87	21	60.91	93	30	68.80	107	50	81.14	112	60	84.63	112	68	86.21	105	65	84.72	95	51	76.20	89	39	67.18	85	22	53.03	76	8	45.80
'87	84	5	43.51	84	14	50.42	95	29	60.86	101	34	67.78	101	43	71.60	107	64	81.14	106	68	86.52	103	63	83.26	100	45	76.66	92	34	62.59	83	21	52.78	73	12	42.26
'88	79	1	40.84	79	28	50.34	91	24	51.78	94	43	66.13	98	51	79.12	104	58	82.07	102	67	86.47	111	61	86.95	98	53	77.48	93	41	67.72	90	28	53.06	75	29	52.13
'89	75	21	46.32	81	17	50.08	85	35	57.20	51	44	69.41	98	43	72.13																					

body, the north winds are severely felt even in this southern latitude. They are, however, of rare occurrence, making their first appearance in the latter part of December and disappearing the first half of April. They last generally from two to three days of which the second day is most severe. Of course it must be understood that this country frequently has winds blowing from the north, but on account of a higher temperature in other seasons they are not uncomfortable. The prevailing winds in this section come from the west and southwest, blowing almost throughout the year, refreshing during the hottest days of the period. The nights are cool and pleasant, due to a generally cloudless sky and a rapid radiation of heat. Though we have before us tables kept since 1868 at this place, a general idea as to the points of the compass from which the winds blow may be well formed from the inserted tables covering the years from 1886 to the present.

Temperature—Is so important that alone it has often been made a ground of classification of climate. An equable climate is understood to have no excessive diurnal variations and from the following tables which show the maximum and minimum and average temperature for the last 20 years, the climate of this country may well be called equable; and, as in this long term of years, the difference between the hottest and coldest month of the year is not excessive, it must also be termed limited; both favorable conditions for the inhabitants. The following exhaustive tables will show this sufficiently.

Rainfall.—The amount of atmospheric precipitation is one of the most important factors in the climate of a country, as the humidity of the air greatly depends on it. It is hardly necessary to mention the great importance of a sufficient amount of rainfall. It determines, with the soils, the success of agriculture and horticulture, and the wealth of a country. The following table, showing the annual and monthly rainfall from 1868 to 1889 will therefore find an appropriate place in this report.

The following table shows that though the rainfall is not abundant it is amply sufficient to mature crops. Even in 1886, the year of the drouth, early crops could have been raised. Settlement, and with it cultivation, will loosen the soil so that the moisture can saturate it and the rain which now falls on dried and hardened prairies, and is drained off as fast as it falls, will be saved and utilized. Large cultivated tracts of orchard and field will serve as condensator, distributing the rainfall, preserving the moisture and causing frequent dews. In a country like this, situated in a southern latitude, with a limited amount of rainfall, the farmer can not pay too much attention to deep and frequent plowing, to a careful cultivation and to setting out of fruit and shade trees. If this is done success will meet the effort. A careful cultivation in a loose soil will not only save the rainfall but also will utilize the dew.

RAINFALL AT FT. CONCHO, SAN ANGELO, TEXAS, SINCE APRIL 1868.

YEAR.	January	February.	March.	April.	May.	June.	July.	August.	Septbem'r	October.	Novemb'r.	Decemb'r.	Total for the year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1868				3.27	4.10	.40	7.30	1.86	2.35	6.40	3.75	1.69	
'69	2.55	.20	2.41	1.10	3.31	3.76	.43	1.94	.50	.96	1.59	1.60	19.82
'70	.16	.16	4.76	62	.26	4.36	3.32	6.90	9.92	5.44	1.24	.12	37.26
'71	—	.54	2.75	1.90	4.40	.42	—	2.04	.90	2.78	.44	.20	16.37
'72	1.28	1.20	—	1 12	1.86	1.50	3.79	2.60	.85	.66	1.66	53	17.05
'73	.16	.33	1.60	—	4.56	6.40	.92	1.46	.41	.08	.25		16.20
'74	.25	.25	1.14	39	3.29	3.05	.88	61	5.58	.64	2.92	5.80	24.90
'75	.05	1.75	.12	.50	1.70	.64	5.67	.22	1 22		.36	2.47	12 25
'76	1.00	.32	.36	.50	—	1.52	.78	3.14	2.84		.52	.68	11.68
'77	—	.98	30	.79	2.12	1.47	.50	2.32	3.60	1.50	1.00	2.00	16 58
'78	—	.10	—	2.32	.02	1.50	4.55	—	6.70	—	1.10	—	17.29
'79	.50	—	.40	1 70	1.10	3.80	.50	4.00	1.00	.20	—	—	13.20
'80	3.90	.60	1.14	.70	1.15	3.20	7.60	3.90	7.20	2.50	.30	.60	32 79
'81	—	—	.20	1.46	6.10	.10	.40	.20	.70	2.30	.50	1.80	13.76
'82	.84	3.38	.35	.09	1.23	2.09	4.14	8.46	3.59	.58	2.05	—	18.91
'83	—	—	3.16	—	—	.76	3.39	2.20	3.36	6.04	.50	60	20.01
'84	.40	.80	.50	4.60	9.08	1.87	2.20	.96	2.00	4.76	1.86	6.21	35 24
'85	4.23	2.15	1.35	3.91	2.33	4.22	1.08	1.35	1.94	.75	—	.70	34.01
'86	.15	.80	.75	.48	.76	1.60	.36	3.74	.56	1.35	—	—	9.55
'87	—	.10	—	1.76	2 86	.66	.93	1.88	2.81	1.74	1.36	.98	15.08
'88	1.10	1.98	.92	3.63	1.55	2.50	3.10	2.50	.48	1 72	2.20	.40	22.08
'89	1.94	2.57	1.15	2.03	2.28								
												Average	19.95

Water.—The Concho rivers are noted for the purity and freshness of their water. Having their source in the Cretacic limestone of the Staked Plains, they drain their southeastern portion. Subterranean waters are generally found in sheets saturating sandy limestone, and sandstone or gravelly deposits; though frequently the well-drill strikes a subterranean stream flowing in fissures of the rocky deposits. Their depth varies from 25 to 100 feet and more. The water procured at various depths is either the local rain which has filtered through the limestone, and sandstone deposits until it strikes an impenetrable stratum and collects on it, or it is the rain and snow falling in the south eastern portion of the plains following these deposits. Like all limestone waters they are clear and sparkling, possessing an agreeable taste. They are charged with carbonic acid and contain carbonate of lime and magnesia in small quantities, small quantities of iron, silica and potash, sometimes sulphates, and little or no organic matter.

SECTIONS OF WELLS IN DIFFERENT LOCALITIES.

Average of wells in San Angelo.

Soil, chocolate color, marly	3 to 10 ft.
Concrete limestone	20 to 50 ft.
Total	23 to 60 ft.

Lipan Flat.

Soil, chocolate color, marly	3 to 10 ft.
Clay, red or yellow	40 to 50 ft.
Limestone	15 to 18 ft.
Total	58 to 78 ft.

Prairie North of San Angelo.

Soil, chocolate color marly	3 to 5 ft.
Clay, red	27 to 40 ft.
Limestone, blue hard	10 to 20 ft.
Sandstone, gray	15 to 20 ft.
Total	95 to 150 ft.

South Concho, 40 miles south of San Angelo.

Soil, calcareous grayish	3 ft.
Limestone, changing in color and density	100 ft.
Limestone and clay of various colors, changing in thin layers	125 ft.
Sandstone, gray	? ft.
Total	228 ft.

Middle Concho, 50 miles west of San Angelo.

Soil, calcareous gray	3 ft.
Limestone, changing in color and density	80 ft.
Clay and Limestone, of various colors, changing in thin layers	150 ft.
White Sandstone	25 ft.
Total	258 ft.

Artesian wells.—All the conditions favoring artesian wells are present:—impenetrable strata, sufficient dip of the formation and water in abundance,—but as the water has to be procured from the Carbonic deposits, it will probably be found brackish, as water has never been found otherwise in this formation in Texas. A few tests have been made, only to affirm the experience gained in other localities. Still these waters are often saturated with common salt, (chloride of sodium), and accompanied with gas, so that perhaps salt works may be established with profit, the gas being used for the concentration of the brine.

Salt wells and other mineral wells.—The clay deposits of the Permian formation in this country are frequently highly impregnated with chloride of sodium, (common salt), and generally contain chlorides of potash and magnesia, with carbonates and sulphates of lime. The water has dissolved these minerals and contains them in solution whenever it has passed through these deposits. A decomposition of sulphates causes them sometimes to contain sulphuretted hydrogen. These wells are not infrequent, and their value in treating diseases of the skin and digestive organs is highly recommended. The artesian water of the Carbonic formation formerly mentioned is, as far as experience goes, always highly saturated with salt and generally accompanied by a flow of gas. The long summer and high temperature during this season, by using the gas, will permit a cheap manufacture of salt.

The soils of this section—Are either derived through disintegration of the Cretacic or Permian strata, and of course their character depends on their source. If derived from the Cretacic along the upper valleys of the rivers and creeks and upon the plateaus, they are highly calcareous, generally of a dark grayish black color; if sufficiently mixed with vegetable matter they are highly fertile, containing all the minerals necessary to support vegetation. The soils derived from the Permian deposits are always of a deep chocolate-red color; they are marly and well mixed with vegetable matter and contain a high percentage of iron-oxide and other minerals always supporting a vigorous vegetation. These soils, easily recognized by their deep red color, cover the lower valleys and uplands for a hundred thousand acres. They are very retentive on account of their argillaceous character and in fertility can not be surpassed.

Building material.—The Cretacic and Permian formations consist, as mentioned before, chiefly of sandstone, limestone and clay beds. The sandstone and limestone vary in character; the former, especially, if taken from the Upper Permian, is a durable stone; the quartz grains are generally small, bound together by a siliceous cement sometimes containing iron, coloring the stone in all shades of yellow, brown and red. The rock is easy to work with hammer and chisel, and very suitable for architectural ornamentation. Examinations in quarry and buildings prove that the rock well withstands the various influences of this climate. The sandstone constituting the base of the Cretacic is generally less desirable, being softer and containing a calcareous cement. Both formations furnish a good limestone, often semi-crystalline and variously colored. On account of its hardness the stone is generally selected for rubble masonry.

Quicklime.—An excellent quality of lime may be obtained by burning the limestone of either formation.

Cement.—The raw material for its product, a mixture of clay, sand, and lime, is found in abundance, which if burned will make cement of good quality.

Clay—Underlies the river valleys. These deposits are variously colored, red, blue and yellow. Suitable for the manufacture of Terra-Cotta, Majolica and pottery.

Irrigation.—The method of irrigating the river bottoms has been practiced since the settlement of this country commenced, almost 15 years ago. The average fall of the rivers and creeks is 10 feet per mile, and a low dam, from 5 to 10 feet, is generally sufficient to raise the water to the level of the land and permit, at low expenditure, irrigation of large tracts of fertile valley land. At the present there are about 16,000 acres under irrigation principally located on Dove creek, Spring creek South Concho and North Concho rivers. The lower uplands, covered with a rich marly soil, can be irrigated by constructing reservoirs. The land is gently sloping along the course of the rivers. Clay underlies the large undulating flats, and the material of the hills is a hard limestone clay and sandstone. The rainfall of the country is sufficient to keep even the largest reservoirs filled during the year, and the cost would be but a trifle in comparison with the benefits derived from such an enterprise.

Grasses.—The principal varieties are: Oat top, which is easily recognized by its reddish color. Though resembling the common sedge grass it is not as coarse and is well liked by stock. Mesquite grass, is of a light green color, growing among the roots of the mesquite bushes in rich and mellow soil, is soft and of abundant foliage and highly appreciated on account of its nutritious qualities. Gramma grass, is of a bluish green color, and though somewhat coarse is very nutritious and never becomes perfectly dry. Running mesquite and buffalo grass are both valuable pasture grasses, forming a dark turf extending over many acres. Both these grasses are exceedingly nutritious. The buffalo grass is said to revive after a rain succeeding a drouth.

Timber.—The rivers and creeks are lined with pecan trees and these with mulberries, and plums often form extensive groves along their bottoms. Upon the large flats grows the mesquite, and the declivities of the hills support a growth of live oak and cedar.

ON THE MAQUOKETA SHALES, AND THEIR CORRELATION WITH THE CINCINNATI GROUP OF SOUTH-WESTERN OHIO

By Joseph F. James, M.Sc., U. S. Geological Survey.

The term Maquoketa shales (pronounced Ma-quo′-ke-tah), was applied to an exposure of rocks of Lower Silurian age by Dr. C. A. White in 1870.[1] The character of the strata referred to this horizon and the reasons advanced for the introduction of the name, are found in Dr. White's report on the Geology of Iowa. The essential portions of his remarks upon this division of rocks are given below. He says ;[2]

> "*Area and General Characters.*—The surface occupied by this formation is comprised within a singularly long and narrow area, seldom reaching more than a mile or two in width, but more than a hundred miles long within the state. It lies like a narrow sinuous band upon the surface between the regions occupied respectively by the Galena and Niagara limestones; having, like them, a northwestward and southeastward trend. Its most southerly exposure is in the bluffs of the Mississippi river near Bellevue, in Jackson county, and the most northerly one yet recognized is in the western part of Winneshiek county.
>
> "The whole formation is largely composed of bluish and brownish shales which weather into a tenacious clay upon the surface, and the soil derived from it is usually stiff and clayey. The shales are sometimes slightly arenaceous, and sometimes calcareous bands compose a considerable part of its bulk. The latter is the case at the typical localities on the Little Maquoketa river about twelve miles westward from Dubuque."

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[1] Geology of Iowa, vol. I. p. 180.

[2] Ibid, pp. 180-182.

"*Geological Age.*—The fossils contained in this formation, together with its position in relation to the underlying and overlying formations, leave no doubt as to the propriety of referring it to the same geological period as that in which the rocks at Cincinnati, Ohio, were formed; but as a formation, it is regarded as distinct from any other one of that group hitherto defined;—the designation 'group' refers to a whole period in geologic time, and when it is applied to any single formation, its indefiniteness differs only in degree from a mere reference of the formation to its proper system or age. Therefore, as the strata of this formation, all referable without doubt to a single epoch of its period, are well developed on the Little Maquoketa river, where its characteristic fossils are also abundant, the name Maquoketa Shales is given to this particular formation of the group."

Dr. White upon the authority of Messrs. Meek and Worthen and upon the strength of his own observations, rejects the term Hudson River group as applied to these shales in Iowa, Illinois and other interior states, and adopts the term Cincinnati group instead, using, he says, "the name Maquoketa shales to designate that particular epochal sub-division or formation of the group which alone is found in Iowa.

"*Fossils.*—Several species of fossils which characterize the Cincinnati group are found in the Maquoketa shales, such as *Orthis testudinaria*, *O. occidentalis*, *Strophomena alternata*, *S.* (*Leptæna*) *sericea*, etc., but they contain a large number of species that have been found nowhere else than in these shales in Iowa. They belong to the genera *Orthoceras*, *Murchisonia*, *Pleurotomaria*, *Schizodus* (?), *Discina*, *Graptolithus*, etc., *The distinct faunal characteristics presented by these fossils last referred to, seem to warrant the separation of the Maquoketa shales as a distinct formation from any others of the group.*[1] Its true position is probably at the base of the group."

It is thus seen that Dr. White considered this division of rocks as a distinct formation mainly for the reason that certain species were confined to the typical locality. The force of this supposition will be considered under the discussion of the fossils.

Having thus given the description which accompanied the original proposal of the name, let us examine the literature which deals with these or rocks of similar age as found in Iowa, in Wisconsin and in Illinois.

The first detailed notice we find of the formation in geologic literature is by professor James Hall. In 1858[2] he published a description of the rocks as observed by him in Iowa, under the name of the "Hudson River group." After noticing the connection between the Trenton and the Galena limestones, mention is made of the Hudson River group and its characters in New York, Canada and Pennsylvania. Toward the west the arenaceous beds are lost and argillaceous and calcareous beds predominate. Beyond Lake Winnebago in Wisconsin, the calcareous shales have been recognized in several places and they were referred by Mr. Lapham to the "Blue limestone" group. Further Dr. Percival recognized the same shales as underlying the limestone of the "Mounds," and described them in his first report of the geological survey of Wisconsin.[4] Professor Hall then goes on to say:

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[1] These last *italics* mine. (J.)

[2] Geol. Survey of Iowa, vol. 1. part 1. pp. 64-70.

"The first indication of the existence of this group in Iowa was observed in some mound-like elevations near the Mississippi river, about eight or ten miles below Gutenberg. On examination these proved to be above the Galena limestone, and their summits capped by the Niagara limestone, with *Pentamerus oblongus*, corals, etc. The slope afforded no opportunity of obtaining a section of the beds between the two limestones; but from the character of the soil, the gentle slope of the hill, and other indications, it was presumed that these beds occur here."

"Our attention was subsequently directed by Mr. Childs to the site of an old mill on the Little Makoqueta, from which some fossils had been obtained, and which, from their previous examination, were inferred to belong to the Hudson River group. At this locality, though the shales were not seen *in situ* above water, it was evident that they had been thrown out in excavating the foundation of the dam; and a slide of gravel and clay on one side of the stream may have covered up what was formerly an outcrop of the same, since fragments are abundant at the margin of the stream. On another branch of the stream, upon the land of Mr. Pitts, there is an exposure of soft shales with calcareous bands containing abundance of *Orthoceratites;* while the shaly strata, in some parts, are filled with *Tellinomya* (*Nucula*) *levata*. The details of this section are given below:

"17.	Top of bank of stream: calcareous bed, compact comminuted shells; a few Orthoceratites.	
16.	Shale with graptolite-like markings	1 foot.
15.	Calcareous bed, with comminuted fossils	1 foot.
14.	Fissile shale	10 to 12 inches.
13.	More compact calcareous bed, with comminuted and minute fossils; some Orthoceratites	18 inches.
12.	Shaly calcareous bed, with comminuted and minute shells	16 inches.
11.	Orthoceratite bed	8 or 10 inches.
10.	Shale	6 inches.
9.	Orthoceratite layer	7 inches.
8.	Shaly calcareous matter	6 inches.
7.	Orthoceratite bed	1 foot.
6.	Shale	7 inches.
5.	Calcareous bed, with Orthoceratites and minute shells	8 inches.
4.	Shale with minute fragments of shells and graptolite-like markings	10 inches.
3.	Concretionary layer	1 foot.
2.	Calcareous bed with minute shells like Orthoceratites	1 foot.
1.	Shale with Lingula, 12 feet from bed of stream	12 feet.

This section is about twenty-five feet in thickness. The *Orthoceratites* are noted as being extremely abundant. "The black shale at the base of the section," Professor Hall says, "is not unlike the Utica slate, and the presence of *Lingula* of a large and small species enhances the resemblance." A similar shale was thrown out of a shaft some two miles west of Dubuque, which contained broken fossils, and in the same vicinity *Nucula* or *Tellinomya* were found. "The entire thickness is probably less than seventy-five feet, and apparently but little more than sixty feet."

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[4] Page 11.

"In consequence of the easterly direction of the river, (Mississippi), the shales of the Hudson River group continue above the water level, and appear at their full development as low down as Sabula; where the cliff at Savannah, on the opposite side of the river, gives a section of some eighty or ninety feet. At this place the calcareous bands have increased in thickness and frequency; and the whole mass has much the same appearance as at Cincinnati, Ohio, and Madison, Indiana. Among the fossils occurring here are *Orthis occidentalis*, *O. testudinaria*, *Strophomena alternata*, *S. filitexta*, and others which do not occur in the exposures of these shales farther to the north." "The shales of this group finally disappear beneath the river before reaching Lyons, at which point the Niagara limestone comes to the level of the river. We shall probably be able hereafter to find some sections of this group farther to the Northwest, which may prove its character and thickness. All the facts at present known regarding it, show that it becomes gradually thinner in that direction; and we infer from the exposures observed, that it does not exceed seventy-five feet in thickness (and is probably less than that) on the branches of the Little Makoqueta Creek.[5] On the Ohio river at Cincinnati it is more than five hundred feet in thickness, while the geological report of Missouri gives to this group one hundred and twenty feet. The great development which it attains in eastern localities, compared with these observations, shows that there is a constant diminution to the westward; and we may expect to find its greatest tenuity or absolute dissappearance from thinning out, somewhere about the head waters of the western branches of Turkey River."

In 1861 professor Hall published[6] descriptions of some new species of fossils from the Potsdam, Trenton, Hudson River and Niagara groups. Among these species were the following from shales overlying the Galena limestone on Little Maquoketa river, in Iowa. *Graptolithus peosta*, *Pleurotomaria semile*. *Cyrtoceras whitneyi*. *Orthoceras gregarium* (afterward changed to *O. sociale*), and *Calymene mammilata*.

In 1862 professor Hall described[7] the series which he had previously referred to the Hudson River group, under the name of "Green and Blue shales and limestones." Among these rocks he places the beds found on the Little Maquoketa river in Iowa, and after quoting the section as given in the Iowa report,[8] gives the details of another section as found near Seales mound in Illinois just south of the Wisconsin line This section is as follows:

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[5] The name is thus spelled by Professor Hall.

[6] Rept. of Supt. of the Geol. Survey (of Wisconsin), Madison, 1861, pp. 52.

[7] Geol. Survey of Wisconsin, vol. I. pp. 47-55.

[8] See ante p. 338.

Greenish shale, with alternations of calcareous and silicious layers, a few inches in thickness	7 ft. 8 in.
Green silico-calcareous and argillaceous shales	11 ft. 6 in.
A silico-calcareous or magnesian band	3 in.
Greenish shale as above	12 ft.
Concretionary layer, one to three inches	3 in.
Shale with Lingulæ	6 ft.
A layer filled with a small Nucula or Tellinomya, and known as the Nucula bed, four to eight inches	8 in.
A calcareous band cut by open joints or fissures, into which the materials of the layers above have penetrated	4 in.
Dark olive shales, finely laminated and destitute of fossils	3 ft. 4 in.
Nucula bed, similar to that above, four to six inches	6 in.
Total,	42 ft. 6 in.

Reference is made in this report to the organic remains and the following species are illustrated but no descriptions are given: ***Nucula* (*Tellinomya*) *fecunda*, *Clidophorus neglectus*, *Pleurotomaria micula*, *P. depauperata*, *Cyrtolites conradi*, *Bellerophon* (*Bucania*) *liratus*, *B. patersoni*, *Theca parviusculus***, and ***Calymene mammillata***[9]

In the same volume[10] professor J. D. Whitney gives an account of the Hudson River shales of the state, in the course of which (pp. 179-180), he gives a section of the strata near Scales Mound station, which is in all essentials the same as that of professor Hall already quoted. He also notes the section on the Little Maquoketa river near Channingsville, Iowa.[11]

In 1866 professor J. D. Whitney[12] mentioned an exposure of the Cincinnati group "near Channingsville, Iowa, on the Little Maquoketa river, first pointed out by C. Childs, Esq., of Dubuque." There is here a section, he says, of "about twenty-five feet of soft shales and layers, crowded with *Orthoceratites*, as well as *Tellinomya* (*Nucula*). Layers made up exclusively of *Orthoceratites*, packed as closely as possible, are seen on the small streams a few miles west of Dubuque."

This reference of the shales to the Cincinnati horizon antedates that of Dr. White by four years. Late Post Office guides contain no such office as Channingsville. The name has probably been changed, and may be now known as Lattners.

In 1876 professor N. H. Winchell in his report[13] on Fillmore county, Minnesota, says under the head of Maquoketa shales:

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[9] The first eight are figured on page 55, and the last on page 432.

[10] Ibid pp. 177-186.

[11] See for this the next reference.

[12] Geol. Survey of Illinois, vol. I. p. 175.

[13] Geol. and Nat. Hist. Survey Minn., 4th Ann. Rept. for 1875, p. 53, 1876.

> "This is the name given to the *Cincinnati group* of shales and limestones, as they appear in Iowa, by Dr. C. A. White, [mis-printed C. M], of the Iowa survey of 1870. Without questioning the correctness of his conclusions that where these shales appear in Iowa they embrace a distinct portion, only, of that series known as the Cincinnati group, his designation is provisionally adopted in our nomenclature. While it is certain that this formation enters the state from Iowa, being seen two miles south of the state line, at Lime Springs, it is still true, that not a single observation has yet been made on it within the limits of Minnesota."

In 1880 Mr. J. F. Whiteaves published[14] a notice of some fossils that had been found at Stony mountain Manitoba. This "mountain" is a hill some fifty feet in hight, on the western bank of the Red river not far from Fort Garry. (p. 49). Mr. Whiteaves says:

> "The collection made by Mr. Ells at this locality shows, first, that a large portion of the mass of Stony Mountain consists of limestones with clayey partings, which are identical, both in their lithological and palæontological characters, with the well known rocks of the Hudson River or Cincinnati group of southern Ohio, and elsewhere; and secondly, that these Hudson River rocks of Stony Mountain overlie, immediately and conformably, the buff-colored, fossiliferous and more or less magnesian limestones of the Red River valley, which have already been assumed to be the representatives of the upper part of the Trenton limestone." (p. 50).

The species recorded by Mr. Whiteaves are as follows:

Chætetes delicatulus Nicholson.
Monticulipora sp.
Monticulipora whiteavesi. ? Nicholson.
Favosites prolificus Billings
Streptelasma corniculum Hall.
Ptilodictya (Stictopora) acuta Hall.
Strophomena nitens Billings.
Strophomena hecuba, Billings.
Orthis testudinaria Dalman.
Orthis sub-quadrata Hall.
Rhynchonella capax Conrad.
Murchisonia gracilis ? Hall.
Cyrtolites ornatus ? Conrad.
Ascoceras newberryi Billings.
Cheirurus icarus Billings.
Calymene blumenbachi Bgt.
[Identified by Billings but it is probably C. callicephala Green].[15]

In 1883 Mr. W. H. Pratt published[16] an account of "An artesian well at Moline, Illinois," a point which is about fifty miles south of Savannah, and a few miles north of Rock Island, Illinois. In this section the Devonian is given at 113 feet; the Niagara at 275 feet; and the Maquoketa at 220 feet, immediately beneath which comes the Galena limestone. Thus at this point the shales have increased to nearly three times their thickness at Savannah, and have sunk 388 feet beneath the surface, showing a dip of over nine feet to the mile.

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[14] Geol. Survey of Canada, Rept. Progress for 1878-79. Montreal, 1880: Appendix I; pp. 49, 50. C.

[15] This paper is alluded to in this connection because Dr. George M. Dawson later on referred to the strata of Stony mountain as probably equivalent to a portion of the rocks of a deep well which he called Maquoketa shales. See reference below.

[16] Davenport Acad. Sci., Proc., vol. 3, pp. 181, 182.

In 1887 Dr. George M. Dawson published[17] some details of a boring at Rosenfeld Station on a branch of the Canadian Pacific railway, in the Red River valley, Manitoba. In this boring the Maquoketa series has an estimated thickness of three hundred and fifty two feet, and consists of grey and red shales, sandstones and limestones. Dr. Dawson correlates the beds represented in this boring with rocks of the same age in Minnesota and Wisconsin. He gives, also, on the authority of Mr. J. H. Panton details of a section at Stony mountain, Manitoba, of rocks for a depth of one hundred and sixty feet. These were pronounced from the fossils, examined by Mr. J. F. Whiteaves to be of Hudson River age. These rocks are supposed to represent the lower two hundred and sixty feet of the rocks of the Rosenfeld well. It would appear from this correlation, that after thinning out very materially toward Minnesota, the shales increase again in thickness to the northward. It may be doubted, however, whether they extend unbrokenly across Minnesota to its northern boundry.

In 1888 professor S. Calvin noted[18] the formations passed through in a deep boring made at Washington, Iowa. He here records that at a depth of 702 feet from the surface there was found a "fine bluish or greenish shale, identical in all respects with shales of the Hudson River group, as seen in the bluffs at and below Bellevue, Iowa. Clay shales, sometimes with an admixture of sand, and again with some calcareous matter, are continued down to a depth of 793 feet. This group of shales are plainly referable to the Hudson River shales of Hall or the Maquoketa shales of White."

This locality is some 75 miles south of the typical locality of the shales. The drift was 350 feet in thickness, which makes the top of the group 353 feet below the rock surface, and we thus have a dip of about 4⅔ feet to the mile, and an estimated thickness of the rocks of 91 feet. It would thus appear that they thin out very materially toward the south as well as toward the north.

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[17] Trans. and Proc. Roy. Soc. Canada, vol. 4, sec. 4, pp. 86-89.

[18] American Geologist vol. 1. pp. 28-31.

In October, 1889, Mr. C. H. Gordon published[19] an article on the geology of southeastern Iowa in which he gives the records of some deep wells bored at Keokuk, Ottumwa and Sigourney. At the former and the latter places the Maquoketa shales were recognized. Keokuk is in the extreme southeast corner of the state, and is about 60 miles south of Washington. Here the shales are recorded as being 63 feet thick and 800 feet below the surface. Sigourney is some 25 miles west of Washington and here the shales were 140 feet thick and 1030 feet below the surface. Not allowing for the drift, the shales at Washington are 702 feet below the surface and 91 feet thick; at Sigourney they are 1030 feet below the surface and 140 feet thick; while at Keokuk they are 800 feet below the surface and only 63 feet thick.[20]

In 1889 Mr. E. O. Ulrich published[21] some notes upon old and descriptions of new species of corals, polyzoa, and ostracods from Stony mountain, already alluded to. Mr. Ulrich calls the rocks "Hudson River or Cincinnati" and in a summary enumerates twenty-nine species of fossils. Of these no less than twenty are also found in the Cincinnati group of Ohio, Indiana and Illinois.

While the references here given comprise all that have been noticed as dealing with the Maquoketa shales, or rocks which have been referred to this formation, it should be remarked that Dr. John Locke in 1839 described[22] the strata and figured a section from the Little Maquoketa River, some seven or eight miles west of Dubuque, eastward to Sinsinewa mound in Illinois. Dr. Locke, however, referred the rocks to a horizon which he regarded as the equivalent of the "Cliff limestone" of Ohio, now known as the Niagara, and placed the lead bearing Galena limestone with the Lower Magnesian of Dr. Owen. He did not recognize the existence of the shales as separating his Magnesian from the Cliff limestone above.

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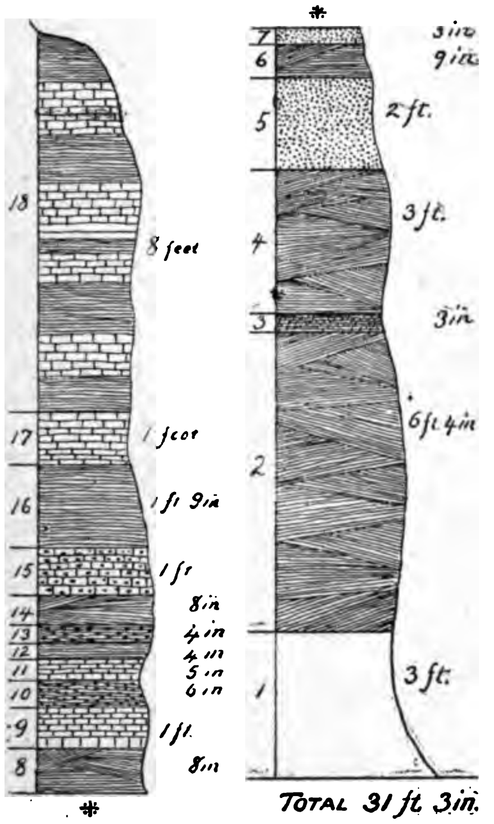
[19] AMERICAN GEOLOGIST, vol. 4, pp. 237-239.

[20] The great thickness of the drift at Washington, 350 feet, is certainly abnormal, and the well was probably located in a river valley. Considerable discrepancy in the depth of the shales beneath the surface and in their thickness, is shown in these well borings.

[21] Contri. to Micro-Palæon. of the Cambro-Silurian rocks of Canada. Part 2. Geol. and Nat. Hist. Survey of Canada, Montreal, 1889, pp. 27-57.

[22] Owen's Survey of Iowa, Wisconsin and Illinois in 1839. Reprint edition of 1844, pp. 152, 153.

A recent visit to the typical locality of the shales in Iowa, for the purpose of collecting the organic remains, under the auspices of the United States Geological Survey, enables me to give details of the rocks as they are at present, and to furnish some more definite information as to their locality than has previously been published.



Section of Maquoketa shales on railroad near Graf, Iowa.

The Chicago, St. Paul and Kansas City railroad, sixteen miles west of Dubuque, Iowa, passes a little station known as Graf. A mile beyond, and a few hundred yards from the railroad crossing, is Lattners Post Office, a small place of half a dozen houses, a store and a mill or two. Between Graf and Lattners is a cut on the railroad and a second one on the wagon road. At the former of these places is an exposure of about thirty feet, the details of which are as follows:

Section of Maquoketa-Shales on railroad near Graf, Iowa.

18. Alternating shales and limestones	8 ft.
17. Limestones formed of finely comminuted shells, a few perfect	1 ft.
16. Thin laminated shales, with Polyzoa	1 ft. 9 in.
15. Limestone with Orthoceras, very abundant	1 ft.
14. Shale similar to No. 16	8 in.
13 Shale with Orthoceras	4 in.
12. Shale	4 in.
11. Limestone like No. 15	5 in.

10.	Shale with Orthoceras, like No. 13		6 in.
9.	Limestone, with Orthoceras, like No. 15	1 ft.	
8.	Shale with many graptolites and small shells		8 in.
7.	Comminuted shells, with Murchisonia		3 in.
6.	Shale with comminuted fossils like No. 8		9 in.
5.	Comminuted shells with a few perfect gasteropods	2 ft.	
4.	Shale with Graptolites and Lingulæ	3 ft.	
3.	Shale with numerous Hyolithes		3 in.
2.	Shale with graptolites etc., like No. 4, but largely barren	6 ft.	4 in.
1.	Covered; probably like No. 2	3 ft.	
	Total	31 ft.	3 in.

The position of these shales and limestones is accurately given by Dr. White. They are the equivalent, and in fact the extension, of a part of the Cincinnati group as exposed in Ohio, definitely limited at the top and bottom. The junction of the series with the Galena limestone is shown on a small branch of the Maquoketa which empties into the main stream a mile or so below Graf. On the river itself at this point the typical, yellow Galena limestone is exposed, in places having a hight of from twenty-five to forty feet. The rock contains very few fossils and is in solid courses varying from four and six to twelve inches in thickness, the layers being separated by a few inches of shale. Following a road which leads up the small tributary, the Galena limestone is seen exposed to a limited extent. About half a mile above the mouth the shales begin to appear, and these a mile further up are to be seen in full force. The shales with graptolites, No. 2 of the section, as well as the layers with Orthoceras, are well shown. The junction of the two series, Galena and Maquoketa, can be observed in the bed of the little creek. The two are quite distinct. The lower one, Galena, is a solid, yellowish limestone, showing a considerable amount of erosion on its upper surface. This is overlain by a tenacious yellow clay and this in turn by the blue shale as seen in the railroad cut. Thus an unconformity by erosion exists between the two formations.

A short distance from the Post Office (Lattners), a small branch comes down from between the hills and empties into the river. Along this ravine there are a few exposures, at a higher horizon than the railroad cut. A yellow clay replaces the blue; the Orthoceras layers are absent, but slabs containing *Leptæna sericea* are found, as are also specimens of *Streptelasma corniculum*. Slabs of a dark, heavy limestone with polyzoa and brachiopods are occasionally found on the hill slopes. Quantities of chert containing a few fossils also occur. There is no vertical exposure but the slope is undoubtedly over the upper beds of Lower Silurian age.

On the opposite side of the railroad from the Post Office is a hill, probably two hundred feet high. On top of this has been opened a small quarry with a face of about fifteen feet, the limestone in courses of from four to six inches, and with considerable quantities of chert in places. Among the *debris* here I found a specimen of *Favosites gothlandica*, indicating a Niagara horizon.

The slope from the bottom of this hill to within about forty or fifty feet of the top is gradual. From this point to the top it becomes quite abrupt, and this abrupt portion probably represents the Niagara limestone. The shales and limestones of the Lower Silurian are easily broken down; but the heavier courses of the Niagara resist atmospheric action and are not so easily affected. The change from a gradual to an abrupt slope is noticeable on all the hills in the vicinity, so that the Niagara doubtless caps all the high ground. Both the Niagara and the Maquoketa disappear toward the east, and as Dubuque is approached the Galena limestone comes to the surface.

In geologic nomenclature it is occasionally expedient to give to exposures of rocks in different parts of the country distinguishing names. It has sometimes been done because the facts at hand have not permitted a correlation of the rocks of two or more widely separated sections of the country. Thus the names Hudson river, Lorraine, Nashville, and Cincinnati have been given to groups of rocks in different parts of the country, though all of them are referable to the same series. The term Lower Magnesian was applied to a series of rocks in the northwest, before it was known that these were of Calciferous age. Le Claire limestone was given to another series because it was thought to be distinct from the Niagara. Similarly Maquoketa was applied to a formation because it was supposed to represent a distinct epoch of the Cincinnati group.

There are certain rules that must govern the coining of new names for formations in new localities. The series of rocks must represent a distinct period in geological time and one that has not been previously named and described. They must be shown to be distinct from previously named series by a difference in lithologic combined with palæontologic features. Or else by showing that the newly proposed group or formation represents a commingling of forms which characterize two or more distinct periods in another part of the country. Such cases as the latter we have in the Anticosti group, where Upper and Lower Silurian species are mingled together in a series of rocks of great thickness and peculiar lithologic characters; and in the Cincinnati group where Lorraine, Utica and Trenton fossils are intermixed.

But where a difference in lithologic characters alone exists without any marked change of fauna or of position in relation to other known groups; or where a horizontal distance separated two eras which were once supposed, but at a later period are shown not to be separated by any great break in continuity; then if a new name be given and a new division formed, it can not readily stand the test of investigation. Thus we believe the Maquoketa cannot retain its autonomy even as a formation distinct from the Cincinnati group for the following reasons:

1. In position with relation to under and overlying rocks they are the same.

2. In lithologic characters there is no difference that can be noted; both consist of calcareous shales and thin bedded limestones.

3. In palaeontological features they are almost counterparts, only a single species out of 41 being confined to the Iowa series; and

4. They are in actual fact, the extension of the Cincinnati group as exposed in southern Ohio.

Of these four reasons we shall take up the last first. We are the better able to examine into this subject because of the extensive search which has been carried on in Indiana for Natural Gas. The underground geology, as professor Orton has termed it, has become an important adjunct to above ground geology. By means of the records of well borings we can trace the extension of series of rocks long after they have buried themselves beneath the surface. The Ohio Geological Survey has taken a leading part in placing upon record and discussing the facts the wells have revealed, and Indiana has done something in this way. But we are especially indebted to the industry of Mr. Frank Leverett, who, while engaged in tracing the moraines of Indiana for the United States Geological Survey, collected such well records as he could in the course of his work, and who has presented the results in a paper published during the past year.[23] In this paper are given the records of 136 wells in Indiana and of 80 or more in Ohio. With the first of these we are especially concerned, and by their aid we shall be able to trace the extension of the Cincinnati group across the state of Indiana. Then from the reports of the Illinois Geological Survey continue the work to the typical outcrop of what has been called the Maquoketa formation in Iowa.

The upper portion of the Cincinnati series is exposed in a few localities in south eastern Indiana. As long ago as 1837, Drs. Locke and Owen noted this extension; and it is well known to geologists that at Richmond and Madison, Indiana, the highest beds of the series are found. The dip being to the westward, and northward, they are soon carried under the surface and are overlain by rocks of Niagara and later ages.

If we take Richmond for a starting point and draw a line due westward we pass less than five miles to the northward of Indianapolis, and touch Illinois about thirty miles north of Terre Haute. Along this line or in its immediate vicinity, never more than ten miles to the north or south, we have records from ten wells. In the following table these ten well borings are given, with the facts necessary for our deductions:

Names of places with wells.	Distance from starting point in miles.	Altitude of rock surface above tide.	Altitude of Cincinnati Group above tide.	Thickness of Cincinnati Group.	
		feet	feet	feet	
Richmond	0	964	964	900	
Cambridge City	18	886	843	684	
Knightstown	38	861	754	665	
" No. 2	38	854	761	642	
McCordsville	63	668	491	543	
Brightwood	71	614	394	541	
Indianapolis	76	640	399	532	These are approximate.
" No. 2.	76	600	379	532	
Plainfield	90	652	17	450	
Danville	96	750	95B.T.	403	

The data in this table, though meagre, show in a sufficiently clear manner the increasing depth at which the Cincinnati rocks are found and the gradual diminution they undergo in thickness toward the west. From a thickness of 900 feet at Richmond, they are only 403 feet at Danville, 96 miles distant; and from a hight above the sea level of 964 feet, the top of the series descends to 95 feet below sea level. The greatest fall in the altitude of the top of the series is between Indianapolis and Plainfield, where in a distance of 14 miles, there is a difference in elevation of 362 feet; while between this and Danville, only four miles west, there is a fall of 112 feet. A well at Terre Haute, some fifty miles west of Danville, was carried to a depth of 2,000 feet and stopped in the Corniferous limestone. With the same dip as that between Plainfield and Danville, the top of the Cincinnati group would be 1512 feet below the sea level; but if the thickness decreased at the same rate as between Danville and Plainfield, it must have disappeared long before Terre Haute was reached.

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[23] Studies in the Indiana Natural Gas Field. AMERICAN GEOLOGIST, vol. 4, pp 6-21, 1889.

Another interesting feature between the two places, Danville and Plainfield, is shown by Leverett's table. This is the wonderful difference in thickness of the Devonian at the two places. At Danville this formation is 570 feet thick, but it thins out to the eastward, so that at Plainfield, only four miles away, it is but 253 feet thick. So that while the Cincinnati group thins out toward the west, the Devonian lying above, diminishes toward the east.

NAME OF STATION.	Distance from starting point, in miles.	Altitude of rock surface above tide.	Altitude of Cincinnati Group above tide.	Thickness of Cincinnati Group.	
		feet	feet	feet	
Richmond	0	964	964	900	
Daleville	43	825	545	505	
Alexandria	63	850	490	305	
" No. 2	63	829	469	305	
Elwood	70	794	403	510	
" No. 2	70	750	433	484	
Windfall	82	778	478	600	
Sharpsville	88	790	390	485	
Fairfield	93	803	418	500	
Kokomo	98	815	415	498	
Flora	121	614	94	306	
Delphi	130	615	45	360	
" No. 2	130	550	5B. T.	313	
Monticello	144	470	35B.T.	300	Estimated.

Returning now to Richmond, and taking a line toward the northwest in the direction of Savannah, Illinois, and the Little Maquoketa river, Iowa, we have records of 14 stations in Indiana. These are arranged in the preceding table.

In this table we find a different series of results. The altitudes of the rock level do not decrease uniformally, though there is such a decrease in general terms. The altitude of the top of the Cincinnati group shows an almost uniform decrease. The thickness of the rocks diminishes from 900 to 305 feet in a distance of about sixty miles, or ten feet to the mile. Then it increases to 600 feet in eighteen miles, and subsequently diminishes almost regularly for forty miles further, for at Flora it is only 306 feet in thickness.

We are unfortunately without definite information concerning the underground geology in the two Indiana counties near the western border. The surface of these is covered with drift, but in Jasper county, near Rensselaer, the Niagara is exposed for about eight feet, and a well was sunk to a depth of over 800 feet into limestone. Part of this is Niagara, part Cincinnati and probably part Trenton.

Mr. Leverett in discussing the features of his table remarks that the Cincinnati axis extends in a southeast and northwest direction, and he demonstrates it by figures relating to the Trenton. We believe the same is shown by the figures given in the above table. It is apparent, at all events, that at Kokomo we are on the slope of the axis, for in the course of twenty miles the altitude of the top of the group above tide, diminishes over 300 feet, or about 15 feet to the mile.

Mr. Leverett refers also to the probable existence of an east and west axis of upheaval as extending from Carroll county westward to Monon and Kentland. At these two places are found outcrops of Niagara limestone, that at the latter place apparently being an isolated fragment in the midst of a Devonian area, and forming an island, as it were, half-way between the Niagara and Sub-Carboniferous formations.

From the reports of the Geological Survey of Illinois we glean a number of interesting facts relative to the rocks of the Cincinnati group in that state. The line we have been tracing enters and crosses the northeast corner of Iroquois county. In the western half of the county the Coal Measures come to the surface. Near its centre a seam of coal eight feet thick, was reported from a depth of 105 feet. To the southwest of this,at a depth of 300 feet, a calcareous shale referred to the Cincinnati group has been found.

The next county in order, Kankakee, is crossed in its southwest portion. The Cincinnati group outcrops at the county line for about ten feet, having risen from 300 feet below the surface in the county to the east. In a boring made in Otto township. a little to the north of our line of section, the Niagara was 388 feet thick. this being the depth at which the Cincinnati rocks were found. while the group itself was 213 feet in thickness.

At Wilmington. in Will county, just north of Kankakee, "there is from fifteen to twenty feet of this (Cincinnati) group exposed in the bluffs of the Kankakee. The lower part is an irregularly bedded argillaceous limestone, which passes upward into green shales. with thin bands of limestone. *Rhynchonella capax* is very abundant here, in addition to most of the species observed at Oswego."[24]

Grundy is the county next west of Kankakee, and here again the Coal Measures predominate. A well at Morris found the Cincinnati group about seventy feet, (69 ft. 10 in.), below the Coal Measures. the intermediate formations being absent. The Cincinnati group itself was 100 feet thick. On the Kankakee river only 50 feet of shales and sandstones intervened between the surface and the Cincinnati group, while in other places the overlying rock is only 20 feet in thickness. In the northeast corner of the county the Cincinnati rocks occupy the north half of the bed of Goose lake, while the Coal Measures occupy the south half. The fossils found in the outcrops in the county are of such common species as *Chætetes lycoperdon, Pleurotomaria* [*Cyclonema*] *bilix, Orthis testudinaria, Leptæna sericea, Ambonychia radiata, Calymene callicephala*, etc. At Minooka the boulder clay lies 100 feet thick upon the rocks of this age.

Kendall county lies immediately north of Grundy. At Oswego, in this county. the junction of the Cincinnati group "with the overlying Niagara limestone is well exposed, and also from eighteen to twenty feet in thickness of the upper part of this group, [Cincinnati]. The upper six feet of the latter, at this locality, is a regularly bedded gray limestone, in layers from six to twelve inches thick. Below this the rock is an irregularly bedded limestone, with intercalations of green shale extending below the bed of Fox river. It affords the following species of fossils: *Strophomena alternata*, *Orthis lynx*, *O. bella-rugosa*. *Chætetes petropolitanus*, *Heterocrinus crassus*, *Dendrocrinus latibrachiatus*, *Porocrinus crassus*, two species of *Nautilus* (one of which appears to be *N. hercules*, of Billings) and *Tentaculites oswegoensis*."[25]

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[24] Geology of Illinois, vol. 1, pp. 138, 139, 1866.

In addition to these *Dendrocrinus oswegoensis*, and *Tentaculites sterlingensis* have been described from this locality.[26] The two species of Tentaculites, since recognized as forms of one, occur also at Cincinnati. In the county under consideration the group is about 71 feet thick, with a slight dip to the northeast.

LaSalle county is next west of Grundy. The formations are here principally Coal Measures. An anticlinal axis crosses the county east of north, and the Trenton rocks are exposed. It is probable that the Cincinnati rocks were once present, but they have been entirely eroded. In the next county to the west, Lee, the rocks are present to a small extent, only about 30 feet.

Our line next crosses the northeast corner of Whiteside county. Here the Cincinnati group is from 10 to 37 feet in thickness, this being the amount exposed at Sterling. It is here a hard, blue limestone, not shaly as it is generally elsewhere, and it overlies the Galena immediately. From Sterling *Dolabra sterlingensis* has been described.

Lastly in Carroll county we reach the Mississippi river and find an exposure at Savannah. Here, we are told, "the lower part of the bed is more calcareous, and consists of thin bedded buff and brown limestone, some layers of which are remarkable for their cleavage into regular diamond shaped blocks. These layers are from two to four inches thick, and contain fragments of Trilobites. The upper portion of the bed at this locality is an ash colored argillaceous shale, with thin plates of limestone thickly covered with fossil shells, among which are *Orthis lynx*, *O. occidentalis*, *O. testudinaria*, *O. bella-rugosa*, *Chætetes petropolitanus* and fragments of *Trilobites*."[27] As already noted the group here is about 80 feet in thickness. We have also seen that professor Hall compares the exposure to that of Cincinnati and Madison, and it is generally recognized as the direct extension of the shales of the Maquoketa River.

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[25] Geology of Illinois, vol. 1, p. 138, 1866.

[26] Geology of Illinois, vol. 3, pp. 333, 343, 1868.

In the year 1862 professor J. D. Whitney[28] mentioned the strata of Paige's Mound in Jo Daviess county, in the northwest corner of Illinois, as "a soft, yellowish, magnesian limestone, with graptolitic markings, and a considerable number of fragments of *Asaphus* (*Isotelus*) *gigas*. These strata on the summit of Paige's mound are identical with a portion of the series observed farther south at Savannah."

We present below in a tabular form the main facts as ascertained in those counties in Illinois, which relate to the Cincinnati rocks:

Counties.	Depth beneath the surface.	Thickness.	
	feet.	feet.	
Iroquois	300		
Kankakee	0–388	213	
Will	0	20	Out of line of section.
Grundy	0–70	100	
Kendall	0	71	Out of line of section.
LaSalle	Absent.	Trenton	outcropping.
Lee	0	30	
Whiteside	0	37	
Carroll	0	80	
Jo Daviess	0	120	

Thus we see that from the last station in Indiana with an estimated thickness of 300 feet, and a depth below the surface of 500 feet and over, the group rapidly diminishes in thickness to 213 feet and 100 feet, and then disappears, while at the same time it rises from over 500 feet below, up to the surface itself. Reappearing again, however, in the course of a few miles and increasing from 30 feet to 120 feet in Illinois, and to probably 200 feet in places in Iowa.

Thus we have traced the rocks of Cincinnati age almost without a break from Richmond, Indiana, to Savannah, Illinois, and have demonstrated that the Maquoketa series is an extension of the Cincinnati group. It will now be necessary to examine the fossil remains from the exposure in Iowa, and see to what extent they differ from those at Cincinnati

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[27] Geology of Illinois, vol. 1, p. 138, 1866.

[28] Geology of Wisconsin, vol. 1, p. 182.

and elsewhere and ascertain whether palæontologic evidence will bear out that of stratigraphy. The following list embraces species which have been identified from material collected by the writer at the typical locality of the Maquoketa shales of Dr. White. In the table the distribution of the species is

List of fossils identified from Maquoketa Creek, Iowa.

Genera and Species.	Iowa.	Illinois.	Wisconsin.	Manitoba.	Cincinnati.	New York.
Spongida.						
Gen. and sp. undet						
Colenterata.						
Monticulipora lens	X		X		X	X
gracilis	X			X	X	X
quadrata	X		X	X	X	
sp. undet						
Streptelasma corniculum	X		X	X	X	X
Hydrozoa.						
Diplograptus peosta=amplexicaule	X		X		X	X
putillus	X					X
Crinoidea.						
Heterocrinus heterodactylus	X				X	X
sp. undet						
Porocrinus crassus	X	X				
Cystidea.						
Lichenocrinus crateriformis	X				X	
Polyzoa.						
Paleschara maculata	X					X
sp. undet						
Brachiopoda.						
Leptæna sericea	X	X	X		X	X
Lingula coburgensis	X				X	
daphne	X		X		X	X
modesta	X				X	
progne	X				X	
whitfeldi	X				X	
Lingulella cincinnatiensis	X				X	
Orthis biforata	X		X		X	X
emacerata	X				X	X
fissicosta	X				X	X
testudinaria	X	X	X	X	X	X
Schizocrania filosa	X		X		X	X
Strophomena alternata	X	X	X		X	X
rhomboidalis, var. tenuistriata	X		X		X	X
Trematis sp. undet						
Zygospira modesta	X		X		X	X
Lamellibranchiata.						
Cleidophorus neglectus	X		X			
Nucula fecunda	X	X	X			
Pterinea demissa	X		X		X	X
Tellinomya obliqua	X				X	
Pteropoda						
Coleolus? sp. undet	X					
Conularia trentonensis	X		X		X	X
Hyolithes parviusculus	X		X		?	
Gasteropoda.						
Murchisonia gracilis	X		X	?	X	X
Pleurotomaria depauperata	X		X			
Raphistoma micula	X		X		?	?
Cephalopoda.						
Orthoceras sociale	X		X			?
Annelida.						
Tentaculites sterlingensis	X	X			X	X
Crustacea.						
Acidaspis crosotus	X				X	
Calymene callicephala	X	X	X	?	X	X
mammillata	X		X			
Beyrichia sp. undet						
Plumulites jamesi	X				X	X

given as far as known. The list of localities embraces Iowa, Wisconsin, Illinois, Manitoba, Cincinnati and New York. It is made thus extensive to show the wide extension of the Cincinnati group, and the absolute connection of the Maquoketa series with the Cincinnati exposure. Out of the 41 species enumerated only 9 species are not found at Cincinnati, with doubt in respect to two of these. This number is likely to be reduced. Out of the 41 only a single species is peculiar to Iowa, though some of them are found only in the adjoining states of Wisconsin and Illinois. At the same time no less than 23 species are found in New York state, with a possible increase in number.

A few observations on some of the species of this list will now be made:

Streptelasma corniculum was not collected by me, but I was assured that it was found frequently in the bed of the creek.

Diplograptus peosta. A form identical with this has been described from the Trenton of New York. Dr. R. R. Gurley, of the National Museum, who is working on a monograph of the Graptolites, thinks it may be the earlier described *D. amplexicaule* Hall. A similar, if not identical species, has been found at Cincinnati.

Heterocrinus heterodactylus was identified from a segment of the column.

Porocrinus crassus identified from a single plate of the body. The markings are so characteristic there can be no mistaking it. Fragments of other species of crinoids were found but have not been identified.

Paleschara maculata was originally described from the Niagara of Indiana. It is impossible to separate the Iowa form from the Niagara. A species of the genus is found in the Lorraine of New York, and another, or a closely related genus in the Cincinnati exposure.

Lingula coburgensis has priority over *L. covingtonensis* Hall & Whitf. The first was described by Billings from the Trenton of Canada; H. & W's. species is from the Cincinnati exposure.

Lingula daphne is Billings's name for the form figured by Hall as *L. attenuata*, Sowb'y.

Colcolus ? sp. This is a very abundant form, and is the only one peculiar to this locality. It varies from straight to curved, though the specimens show little variation in size. It is about 10ᵐᵐ in length, and 1ᵐᵐ in diameter at the base, tapering to a sharp point. A slender groove extends along one side. Occasional specimens show what appear to be a series of joints. In section it is circular. It is so abundant as to make up certain layers of rock, and at times specimens are collected in groups as if swept together by currents and entangled in a mass. Should this prove to be a new species, I propose the name of ***Iowaensis*** for it.

Hyolithes parviusculus Hall is interesting as belonging to a group which was largely developed in Cambrian time. It is associated in the same beds with the preceding, though not nearly so abundant. t is probably this form which was catalogued[28] as occurring at Cincinnati under the name of *Hyolithes americana* Billings. This is, however, a Cambrian form according to Walcott.[29] Mr. Walcott has described[30] *H. vanuxemi*, from the Pogonip (Lower Silurian) of Nevada, which is possibly identical with Hall's species as above. In cross section, what appears to be a siphuncle, sub-central, is occasionally to be observed.

Raphistoma micula, Hall, originally described as *Pleurotomaria micula*, is in all probability the same as *R. subtilstriatum* from the Trenton of New York. A figure, but no description of it, is given by Hall in the Geology of Wisconsin, p. 55, 1862. A comparison of the Iowa specimens with forms from Cincinnati show that *R. micula* occurs at Cincinnati, though it has been recognized under another name. In fact *R. micula* is a synonym for *R. subtilstriatum*.

Orthoceras sociale, Hall, originally described as *O. gregarium*, was changed by professor Hall in Miller's catalogue Palæozoic Fossils, p. 245, 1879. This was the only species of cephalopod found. The specimens vary from one-fourth of an inch to three inches in diameter. Only a few of the latter were obtained. Some of the smaller and better preserved specimens show transverse lines such as are seen in specimens of *Endoceras proteiforme*, and as shown by figures given by professor Hall. In other specimens where the outer surface of the shell is worn off, the septa are shown. These vary from 4 to 10 in the space of an inch. The siphuncle is central. Many specimens retain the nacreous exterior. A few show the body chamber, and one or two of these are very similar to *Endoceras proteiforme* var. *strangulatum* as figured by professor Hall. It is a question whether this species is not really the same as certain forms described as Endoceras from New York.

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[28] Ulrich, Cat. Foss. Cin. Group, 1880; also James, (J. F.) Cat. Foss. Cin. Group, 1886.

[29] Bull. U. S. Geol. Survey No. 30, p. 132, 1886.

[30] Mon. U. S. Geol. Survey, vol. 8, p. 85, 1884.

Tentaculites sterlingensis. Professor Hall has lately shown[31] that forms described as Tentaculites, Ortonia, Conchicolites, Spirorbis, etc., are really only certain phases of development of *Cornulites incurvus* Shumard. Whether this be so or not, there can be scarcely any doubt but that *Tentaculites oswegoensis*, *T. sterlingensis*, *T. minutus*, and *T. richmondensis* are all the same species. The differences are too slight to base species upon.

Plumulites jamesi. A few plates of this species showing the characteristic double curve were found. It is interesting as extending the range of the species from New York to the Mississippi. A single plate of a form of this genus is noted as having been found in the Pogonip of Nevada.[32]

In respect to the lithologic features of the Cincinnati group and Maquoketa shales we have seen that they are identical. Professor Hall refers to the close resemblance the rocks at Savannah bear to those of Madison and Cincinnati, at all three of these localities consisting of intercalated shales and limestones. The same fact has been recognized by other writers.

Lastly the position of the shales in relation to over and underlying formations is identical with the Cincinnati group, the Trenton lying below and the Niagara above in both instances.

With all these facts in view, namely, that the Maquoketa shales are the almost direct continuation of the Cincinnati series; that the palæontologic features of the two are almost identical; that the lithologic features of the two are the same, and that the position of the two in the geological scale is the same, it does not seem wise to retain the name Maquoketa as a distinct formation. It would seem better to consider the rocks as part of the Cincinnati series, dropping the term Maquoketa altogether.

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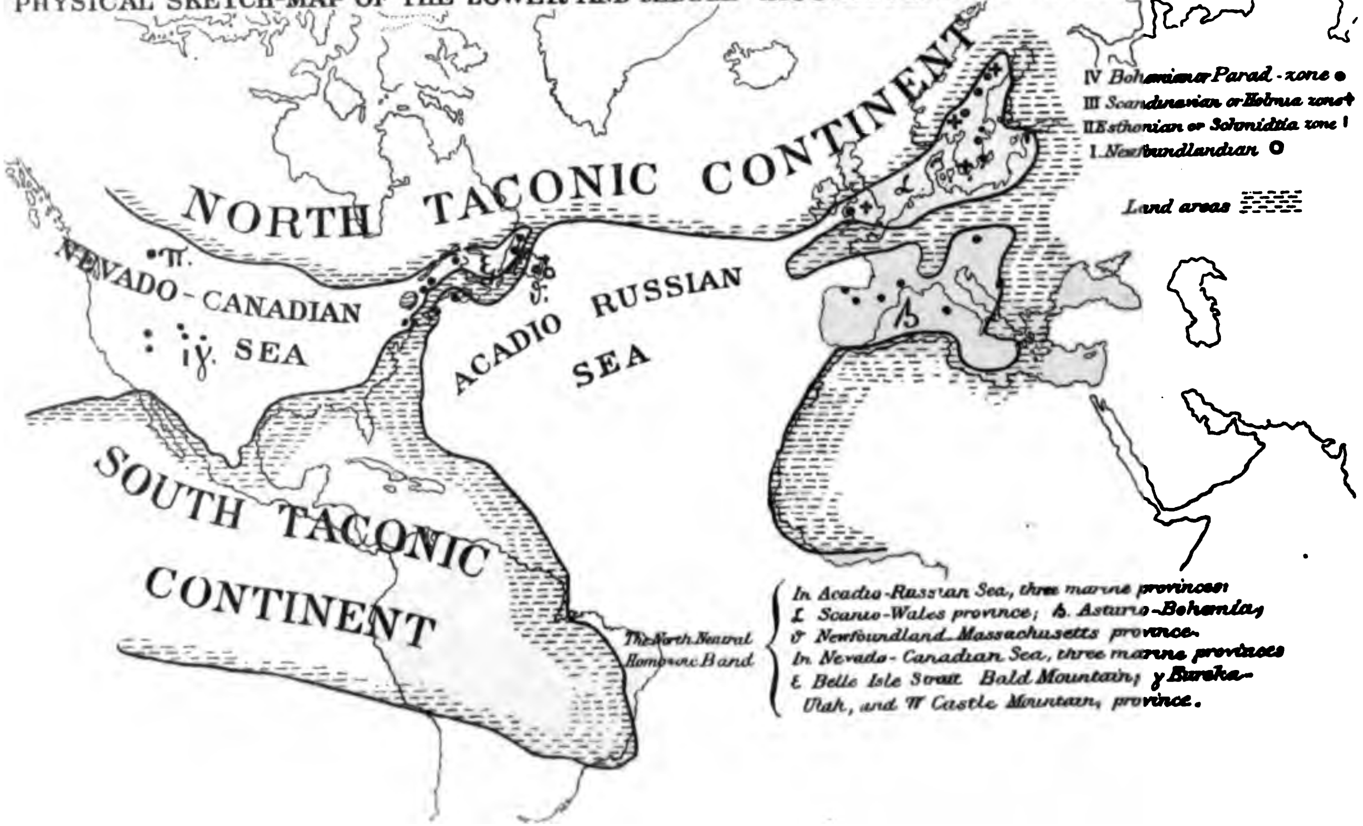
[31] Palæon. of New York, vol. 5, part 2, pp. 163-166, 1879.

[32] Mon. U. S. Geol. Survey, vol. 8, p. 88, 1884.

PHYSICAL SKETCH-MAP OF THE LOWER AND MIDDLE TACONIC PERIOD, BY JULES MARCOU. 1889


IV Bohemian or Parad.-zone ●
III Scandinavian or Holmia zone ✝
II Esthonian or Schmidtia zone !
I. Newfoundlandian ○
Land areas
NORTH TACONIC CONTINENT
NEVADO-CANADIAN SEA
ACADIO RUSSIAN SEA
SOUTH TACONIC CONTINENT
π.
ιγ.
ε
ϑ.
ℒ
ϐ
The North Neutral Homozoic Band
In Acadio-Russian Sea, three marine provinces:
ℒ Scanio-Wales province; ϐ. Asturo-Bohemia;
ϑ Newfoundland-Massachusetts province.
In Nevado-Canadian Sea, three marine provinces
ε Belle Isle Strait Bald Mountain; γ Eureka-Utah, and π Castle Mountain, province.

THE LOWER AND MIDDLE TACONIC OF EUROPE AND NORTH AMERICA.

By Jules Marcou, Cambridge.

I.

Introduction.—The conclusions of my paper: "The Taconic system and its position in stratigraphic geology," (*Proceed. Amer. Acad. Arts and Sciences*, new series, vol. xii, p. 255, Cambridge, 1885), are that the Taconic system comprehends all the strata in which the primordial faunas are found. These faunas are three in number. The Infra-Primordial or Lower Taconic, the Primordial or Middle Taconic, and the Supra-Primordial or Upper Taconic. In the same paper, at p. 224, there is a "Tabular view of the Taconic system in eastern North America," in which I have tried to classify in a single column the Taconic series of the lake Champlain region (Vermont, Canada and New York) and of the extreme borders of the Atlantic (Newfoundland, New Brunswick and Braintree). It is condensed below as follows:

Supra-Primordial.	Potsdam group.	
	Swanton slates.	
	Phillipsburgh or Pointe Lévis group.	
Primordial.	Georgia slates or *Olenellus* (*Elliptocephalus*) zone.	
	St. John or Acadian group.	Paradoxides zone.
	Argillites of Braintree and St. Mary's bay.	
Infra-Primordial.	*Eophyton* sandstone of Great Bell Island.	[Newfoundland.]
	Aspidella and *Arenicolites* slates of St. John's.	

Four years later I called the attention of observers to the existence of "an uninterrupted sea" extending from Scandinavia to eastern Newfoundland, and that "during the Taconic time, an arctic continent existed from the Scandinavian Alps to Scotland, Greenland and Labrador, and was united with an equatorial continent by a narrow region, somewhat similar to the isthmus of Darien or Panama, which connects the continent of North America with the continent of South America. That Taconic isthmus formed the barrier between the Atlantic and Pacific oceans of that remote period of our globe." ("Canadian geological classification for the province of Quebec," extra from *Proceed. Boston Soc. Nat. Hist.*, vol. xxiv. pp. 75 and 76, Salem, 1889).

I propose now to show more plainly the existence of those two oceans, limiting each one to a special region, sufficiently explored so as to allow a great separation between the Taconic series; and at the same time to give a more complete tabular view of the strata which were deposited in the Acadio-Russian and in the Nevado-Canadian seas. Those two names indicate, with more exactness, the extent of sea waters during the Taconic epoch, and are preferable to the use of the Atlantic and Pacific oceans of that very remote period, because we are unable, in our present state of knowledge, to give any idea of their extent in any direction outside of the areas of Acadio-Russia and Nevado-Canada. I shall confine my remarks to the Lower and Middle Taconic, leaving the Upper Taconic for a special study.

ACADIO-RUSSIAN LOWER AND MIDDLE TACONIC.—In the Acadio-Russian sea we have the following formations distributed at special and rather isolated points, as mere patches and remains of vast formations concealed since by the strata of all the systems which have been deposited since the Taconic period.

Tabular view of the Lower and Middle Taconic of the Acadio-Russian sea.

IV. Bohemian formation or *Paradoxides* zone.
III. Scandinavian formation or *Holmia* zone.
II. Esthonian formation or *Schmidtia* zone.
I. Newfoundlandian formation.—No trilobite found yet.

I. NEWFOUNDLANDIAN FORMATION.—It would have been better to use the name *Terranovian*, but Mr. T. Sterry Hunt has called in his chemical classification of the crystalline rocks, a certain class of them *Terranovian*, it is true without any very definite value as regards superposition, relative age or even lithological characters, but which may create confusion. More recently Mr. C. D. Walcott has used the name *Terra Nova division* for the strata of a part of the peninsula of Avalon in Newfoundland, which he has erroneously synchronized with the Georgia slates of Vermont. ("Position of the *Olenellus* fauna, etc," *Amer. Jr. Sci.*, vol. xxxvii, p. 383, 1889). In order to prevent all confusions and claims of priority, and desirous also to maintain in classification the name of a country so eminently well fitted to be remembered, and which will become more and more the typical area of the Taconic system, I propose to use the name ***Newfoundlandian***, in French *Terreneuvien*, for the first great group containing fossils at the base of the Taconic.

Below the strata containing *Paradoxides* there exist in many places, sandstones, slates, quartzites and even limestone bands, sometimes rather thin, but often of great thickness, in which fossils are extremely rare. Lately, in the Russian Baltic province of Esthonia, a well marked fauna—but still a very small one—has been found in the uppermost part of those strata, and in it the oldest trilobite yet known, not a *Paradoxides*, but an old form allied to it.

During the last forty years announcement of the discoveries of fossil remains—generally of doubtful nature—has been made, in those inferior strata near their junction with the Primitive rocks. The specimens called *Eozoon canadense*, thanks to the sensational character and desire of notoriety manifested by those interested in them, have rapidly become celebrated. In 1861, during a visit to the Museum of the Geological Survey of Canada at Montreal, the director, Logan, showed me a polished specimen of rock, asking my opinion. After looking at it carefully I said: "I do not see any organism in it; send it to Delesse or any other distinguished lithologist if you want an exact definition." Two years after I was rather surprised to see that Messrs. Dawson, Carpenter and Jones had made it out an organism, under the generic name of *Eozoon*. Directly *Eozoon* was signalized as existing in almost all the crystalline Primitive rocks of Europe and America. If truly organic, then we have found a fossil, not only in the oldest stratified beds of the Transition strata called until then *Azoic*, but even among the Primitive formations. But King and Rowney in a well digested and very careful study, have demonstrated the non-organic character of the specimens, and Perry and Burbank in Massachusetts, and professor Mobius in Germany gave a final check to that much doubted discovery.

Dr. Emmons has described in his "Geological Report of the Midland counties of North Carolina," pp. 61-64, 1856, two specimens regarded by him as corals of a lenticular form, under the names: *Palæotrochis major* and *minor*. He found them in Montgomery county, North Carolina. The organic nature of those specimens has been contested; and although it is certainly less objectionable than for the *Eozoon*, it is best to wait for more careful studies before giving a final opinion.

Obscure forms of supposed *fucoides* and burrows of marine worms called *Arenicolites* and *Scolerites*, have been signalized and described in those inferior beds of the Transition period in Bohemia, Scandinavia, Great Britain, Portugal, Spain, Newfoundland, etc. But until now the only specimen of an organic structure certain and indisputable is the ***Aspidella terranovica*** Billings, compared to a small ***Chiton*** or ***Patella***, flattened by pressure. It was found in 1866 by A. Murray near St. John's, the capital city of Newfoundland, in the slates called in 1843 by Jukes: "St. John's slate," and placed by him at the base of his "slate formation." Murray and Howley call them: "***Aspidella*** slates" of the Huronian rocks ("Report Geol Surv. Newfoundland for the year 1881, appendix, pp. 2-3. St. John's 1882; and "On some fossils from the Primordial rocks of Newfoundland" by E. Billings, in ***Canadian Naturalist***, vol. VI, p. 478, July, 1872).

If we consider the column of Primordial strata, published by the geological survey of Newfoundland in 1870, all the strata below divisions *m* and *l* in which ***Paradoxides*** or more exactly *Holmia*, make their apparition, we have in divisions *k*, *j*, *i*, *h*, *g* and *f* a group of strata with ***Archæocyathus***, fucoids and annelid (*Arenicolites*) tracks, which very likely is the equivalent and homotaxis of the following formation, called II. Esthonian formation of the gulf of Finland, in which we may expect to find in Newfoundland one day or another the small fauna of the vicinity of Reval (Russia). Below, in divisions *e*, *d*, *c*, *b* and *a* of the column of the Newfoundland Primordial strata, 1,500 feet thick, composed mainly of sandstone, quartzites and slates, we have a great group in Trinity bay, which seems to be represented round St. John's by the conglomerates, Signal Hill sandstone, and *Aspidella* slates, and the whole constitute the most inferior part of the Lower Taconic of Newfoundland, which I think it is proper to call Newfoundlandian (*Terreneuvien* in French) formation. Until now that formation has not yet furnished any certain fossil organism except *Aspidella*. No trilobite has been discovered yet, although they will probably be ferreted out some day.

The Newfoundlandian formation constitutes the base of the Taconic system, and with the following great division, the Esthonian, they form together the Infra-Primordial fauna existing on our globe.

II. ESTHONIAN FORMATION.—A Russian geologist, the engineer A. Mickwitz, discovered in 1886 some primordial fossils at two different spots near Reval in Esthonia, (close by the shores of the gulf of Finland); and a year later, in 1887, he found good fragments of a trilobite of the Paradoxidean type. He placed fossils and sections with all his notes in the hands of professor F. Schmidt, a fellow of the Imperial Academy of St. Petersburg, who read a most interesting paper before that academy, the 16th February, 1888, under the title: "Ueber eine neuentdeckte untercambrische fauna in Estland." *Mém. Acad. Imp. Sciences, St. Petersbourg*, VII série, tome XXXVI, No. 2). Later on, in November 1888, professor F. Schmidt read another paper: "Weitere Beiträge zur Kenntniss des *Olenellus mickwitzi*" (*Bulletin Acad. Imp. Sciences, St. Petersbourg*, tome XXXIII, p. 191).

The résumé of the discoveries of both Mickwitz and Schmidt is: that below the "Fucoid sandstone" of Sweden, recognized without any possible doubt near Reval, there exists at Strietberg a series of blue clay with subordinate layers of sandstone six hundred feet thick, resting on the Finland granite. In the upper beds of the blue clay the following fossils have been found: *Olenellus mickwitzi*, *Scenella discinoides*, *Scen.? tuberculata*, *Mickwitzia monilifera*, *Obolella? Discina? Volborthella tenuis*, *Platysolenites antiquissimus*, *Medusites lindstroemi*, *Primitia?* and *Fraena tenella*. All the forms of these fossils are very old; and a study of the two plates which accompany the important memoir of professor Schmidt impresses the idea that we have there the oldest fauna yet found. It is not that no other fossil exists, and that we do not possess already a few traces of fossil remains found below the Esthonian as we have seen previously in the Newfoundlandian; but it is a fact that until now no collection of a certain number of fossils, sufficiently numerous to be called a fauna, has been found, as old as the Esthonian fauna of Russia. Several of the forms of these fossils, more especially the only trilobite found, which is the oldest trilobite so far known in the world, indicate that something older must exist, and that one day more fossil animals will be found at a lower stage than the Esthonian formation, in the Newfoundlandian strata.

In regard to the trilobites, justly regarded as the most important and useful family of fossils for the Palæozoic series, as the Cephalopoda are for the Mesozoic series, the two most primitive forms, with the simplest organization, are *Agnostus* and *Microdiscus* which have not yet been found in the Infra-Primordial fauna or Lower Taconic.

Professor Schmidt in his excellent and very carefully made description of the Esthonian trilobite has called attention to its close affiliation with ***Paradoxides***, ***Olenellus*** (***Elliptocephalus***), ***Olenoides*** and ***Mesonacis***, all genera of true Primordial types, revolving round the great Paradoxidean type, so well characterized by Barrande. ***Elliptocephalus*** (***Olenellus***), ***Olenoides*** and ***Mesonacis*** are all sub-genera created at the expense and as off-shoots of the great genus ***Paradoxides***; for it is worthy of remark, that at first, when found in fragments—as is invariably the case—all the trilobites, which are referred now to ***Olenellus*** (***Elliptocephalus***), ***Olenoides*** and ***Mesonacis*** were regarded as fragments of ***Paradoxides***.

The name ***Olenellus***, so extensively used lately, is as improper, as it is incorrectly applied. Barrande and Matthew have shown that the trilobites referred to ***Olenus*** and afterward to ***Olenellus*** by James Hall, have more affinities with and are closely allied to ***Paradoxides***, instead of being truly of ***Olenus*** forms. When right of priority, regarded as an immutable law in every department of natural history, shall be applied also to Dr. Emmons' primordial fossils, described as far back as 1844, then the name ***Olenellus***, created only in 1862, will be suppressed and replaced by ***Elliptocephalus***; for Emmons not only saw that the first trilobite he found in his Taconic system was a new form, but he had the acumen to see its relation to ***Paradoxides***. ("Manual of Geology," p. 88, 1859, and second edition, p. 280, 1860), before Barrande pointed it out in his celebrated memoir of 1861 ("Documents ancients et nouveaux sur la faune primordiale et le système Taconique en Amérique," pp. 273-277). On the contrary Mr. James Hall referred the trilobites of Bald mountain and Georgia in 1847 and 1859 first to ***Olenus***, from which they differ greatly, and afterward in 1861 to ***Barrandia***, a succession of errors rare in palæontology, not to speak of the stratigraphic error of placing the primordial fauna above the second fauna, which is even more glaring. That the priority of Emmons' name will be recognized, is only a question of time. Without knowing the existence of the genus ***Ellipsocephalus***, he, with his great palæontological acumen, recognized in the Bald mountain trilobite a general form, which has been shown since to be characteristic of the Primordial fauna, and he called it ***Elliptocephalus***: as he says: "the name, from its similarity, is no doubt objectionable, but I am disposed to retain it for the present." ("American Geology," p. 114, Albany, 1855). So, until an understanding is reached among palæontologists to replace Emmons' original name by another which shall be acceptable to the memory' and respect due to the discoverer, it is best to use Emmons name of *Elliptocephalus* as he expressed it.

In the case of the trilobite of Kunda and Strietberg near Reval, it is not an *Elliptocephalus* (*Olenellus*) of the Georgia typical form *Elliptocephalus*(*Olenellus*)*thompsoni*,on account of its pygidium totally different, its head remarkably large and elongated; and finally the thorax also presents great differences in the lobes, and in the existence in the middle of the thorax of spines (like the genus *Holmia*), one of which on the eighth articulation, is a spade-like form or telson, trespassing over the pygidium, and having a length as great as the elongated head. In reality this trilobite possesses generic differences and constitutes a new sub-genus, closely allied to ***Paradoxides***, and in which may be included ***Mesonacis vermontana*** and *Olenoides typicalis*, the latter being an extreme degenerate form of the type. I propose to call it *Schmidtia*, in honor of professor F. Schmidt.

I shall call the group of strata found at the two places in the vicinity of Reval, ***Esthonian** formation* or *Schmidtia zone*: a new group not yet found anywhere else, so far as fossil animals are concerned, and which is placed at the top or uppermost part of the Lower Taconic or Infra-Primordial. It corresponds stratigraphically with the ***Eophyton*** sandstone of Sweden, the "Sparagmite stage" of Norway, and the beds below division *m* of the Newfoundland column of lower palæozoic strata, in Conception bay.

As a résumé, of the Infra-Primordial, the first great group or Newfoundlandian formation contains, so far, only one certain species of fossil, the ***Aspidella** terranovica* with indications of remains called *Arenicolites*, fucoides and *Archæocyathus*, more or less problematic; and the second great group or Esthonian formation contains eleven species, making for the whole of the Infra-Primordial fauna only twelve fossils.

III. Scandinavian formation.—*Sweden and Norway.*—We come now to the Middle Taconic, the Magnesian and Black slates (*a* and *e*) of Emmons, the *Regio II Olenorum*=*A* of

Angelin, the division *c*, or the true Primordial fauna of Barrande.

Dr. A. G. Nathorst, when exploring the celebrated locality of Andrarum, in Scania, in 1868 and 1869, found below, what was then considered the oldest *Paradoxides* beds, or Regio A of Angelin, another trilobitic zone or group of strata containing a *Paradoxides*-like form, an *Ellipsocephalus*, an *Arionellus* and a *Lingula*. Professor O. M. Torell, director of the geological survey of Sweden, named the *Paradoxides*-like, *Paradoxides walhenbergi* and at the same time he named the beds: "the *Paradoxides walhenbergi* strata;" but he did not give any description or figure of the *Paradoxides*.

In 1870 Linnarsson discovered in Norway, near lake Mœsen, the same lower horizon of the Primordial zone, naming and figuring the *Paradoxides*-like form, *Paradoxides kjerulfi*; ("Om nogra fœisteninger fraon Sveriges och Norges Primordialzon," 1871). My lamented friend the late professor Kjerulf in his "Sparagenitf jeldet," published in 1872, gives also good drawings of that trilobite under the name *Paradoxides kjerulfi*. In 1876 Linnarsson recognized that the *Paradoxides kjerulfi* was identical with *Paradoxides walhenbergi* of Torell. The celebrated geologist and palæontologist, professor W. C. Brœgger, when working under the direction of his teacher, professor Kjerulf, on the geological survey of Norway, recognized during the summer of 1877, an excellent station of that older horizon of the *Paradoxides* zone at the station of Krekling, northeast of Christiania, and he published in 1878, in *Nyt Magazin for Naturvidenskalume*, tome XXIV, 1, Christiania, a most important and interesting paper entitled: "Om Paradoxides skifrene ved Krekling." In it professor Brœgger changed the reference by Torell and Linnarsson of *Paradoxides*, into the genus *Olenellus* Hall, and he called that trilobite first discovered by professor Nathorst *Olenellus kjerulfi*. Brœgger does not give any figure, but refers to the drawings of Linnarsson, Kjerulf and Angelin.

When professor Brœgger made this reference there was not a single complete and well preserved *Elliptocephalus* (*Olenellus*) figured and described. He took for the type of *Olenellus* the figure given by Mr. J. Hall, in February, 1861, in his second edition of his "Note upon the trilobites of the shales of the Quebec group in the town of Georgia, Vermont" (*Thir-*

teenth Ann. Rep. State Cabinet Nat. Hist. of New York, Albany, March, 1861), which at p. 116, under the name *Barrandia thompsoni*, gives a figure,[1] most inexact in many important genetic points, of the already celebrated Georgia trilobite. The head, thorax, and more especially the pygidium figured and described by Mr. Hall are very defective and misleading. So it is not astonishing that professor Brœgger made the mistake of referring the Scandinavian trilobite of Nathorst, Linnarsson and Kjerulf to *Olenellus* (*Elliptocephalus*).

As far back as 1862, in one of my numerous visits to Georgia, I found a complete specimen of the so-called *Olenus*, *Barrandia* and *Olenellus thompsoni*, but by some mischance my specimen was not figured and described until February, 1884, by Mr. R. P. Whitfield in the *Bulletin Amer. Museum Nat. Hist.* vol. I, No. 5, plate XV, fig. 1, and p. 151, New York. Mr. Whitfield corrected the description and figure of Mr. Hall to such an extent as to make almost not only a new species, but also a new genus. The remarkable length of the pygidium, or rather caudal spine, as he says, is "a generic distinction." If professor Brœgger had seen that figure and description of Mr. Whitfield, he would not have referred his Scandinavian trilobite to *Olenellus*. It was reserved to Dr. Gerhard Holm, to give in 1887, a most elaborate and truly reliable description and figure of the Scandinavian type of that contested trilobite, first placed in *Paradoxides* and afterward in *Olenellus*. In his paper "Om *Olenellus kjerulfi*," Dr. Holm shows generic distinctions; more especially for the pygidium, which is as nearly as possible a *Paradoxides* pygidium, and completely different from the spare-like or telson pygidium of *Olenellus*; also thoracic differences; and finally the "growing together of the cheeks with the middle part of the head and the peculiar elongation of the suture." A study of Dr. Holm's excellent figures and description lead forcibly to the opinion that *Olenellus kjerulfi* is not an *Olenellus* (*Elliptocephalus*) at all, but a new genus intermediate between *Paradoxides* and *Elliptocephalus*, more closely related to *Paradoxides*, its most immediate successor in chronological order, on account of the pygidium; and I fully concur with Mr. G. F. Matthew who had proposed to use the name of Dr. Holm for the new genus;[2] and in future I shall call it *Holmia*, and the species under consideration *Holmia kjerulfi*.

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[1] The figure was drawn from more or less fragmentary specimens.

Linnarsson gave in 1876, ("On the Brachiopoda of the *Paradoxides* beds of Sweden, at p. 7), a classification and nomenclature of the *Paradoxides* beds of Sweden, in which he recognized at least six divisions; each one containing its peculiar fossils.

These groups or palæontological horizons are arranged as follows, in descending order:

6. Strata with *Agnostus lævigatus.*
5. id id *Paradoxides forchammeri.*
4. id id *Paradoxides œlandicus.*
3. id id *Paradoxides davidis.*
2. id id *Paradoxides tessini.*
1. id id *Paradoxides kjerulfi.*

Professor Brœgger, in 1878, refers all the *Paradoxides* beds of Norway to three divisions which he calls in descending order:

Etage 1d. Krekling with *Paradoxides forchammeri.*
Etage 1c. Krekling with *Paradoxides tessini.*
Etage 1b. Ringsaker and Kletten with *Olenellus* (*Paradoxides*) *kjerulfi.*

The special generic form of *Holmia* (called *Paradoxides* and *Olenellus kjerulfi*) found in Etage 1b in Norway and in division 1 strata with *Paradoxides kjerulfi*, in Sweden, coupled with the great importance accorded lately to that subdivision of the Scandinavian Middle Taconic, leads me to propose the name *Scandinavian group* or *Holmia zone* for it.

Besides the characteristic *Holmia kjerulfi*, other fossils have been found; and professor Brœgger in his paper of 1878 quotes: *Arionellus primævus*, *Obolus? Discina? Acrothele?* and *Hyolites*. Dr. Holm adds to this list for Sweden: *Ellipsocephalus nordenskioldi*, *Metoptoma* and *Lingulella? nathorsti.*

So far, only four localities of the Scandinavian group have been found in the Baltic region; the first one near Andearum in Scania (Sweden), two near Krekling in Norway, and the last one in southern Lapland, on the river Umea. Found only in 1885 by Mr. E. Moersell, the primordial fauna of Lapland has not yet been published; it contains not only the *Holmia* zone, but also the *Paradoxides* zone. Dr. Holm wrote me lately that during this winter he will issue a memoir, in which he will describe all the material he has collected for several years, having the kindness to send me a map, on which he has localized not only the Lapland area of Taconic outcrops, but also all the other patches of Scandinavia and Esthonia.

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[2] "On the classification of the Cambrian rocks in Acadia" (*Canadian Record Sc.* vol. III, p. 76), Montreal.

British-Scandinavian formation. Until now, in Europe, the only other locality where the Scandinavian group has been found, is in Great Britain, where lately, 1888, professor C. Lapworth has signalized its existence on the flanks of Caer Caradoc (Shropshire). Besides an *Holmia* (*Olenellus*) which he has previously named *callavei*, professor Lapworth quotes the following fossils: *Kutorgina*, *Mickwitzia?* and *Acrothele*. The sandstones and calcareous beds containing those fossils are succeeded irregularly by the Lower Tremadoc strata. ("On the discovery of the Olenellus fauna in the Lower Cambrian rocks of Britain," in *Geol. Magazine*, Nov. 1888, pp. 484-487, and reprinted in *Nature*, Dec. 27, 1888).

From the dates it follows that English geologists many years after the discoveries of Messrs, Nathorst, Linnarsson, Brœgger and Holm, have at last found the *Holmia zone*, just as they found only many years after Barrande's discovery of the *Paradoxides* zone in Bohemia, the *Paradoxides* beds of St. David; and of course, many years after Dr. Emmon's great discovery of a special fauna in his Taconic system. It is only just to insist on the date of discoveries in everything which partakes of the Primordial, because British geologists have assumed the naming and classifying of all the strata below the Carboniferous system, as belonging to them, without any regard to priority of discoveries by other nations and other geologists.[2]

Newfoundland's Scandinavian formation.—Outside of Europe, in the same Acadio-Russian sea, on the edge of the *terra firma* of the Taconic period, another patch of Scandinavian group or *Holmia* zone, has been recognized in Conception bay, eastern Newfoundland.

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[2] "M. Geikie: La question de la classification des roches cambriennes et siluriennes est avant tout une question anglaise" (*Congrés géologique international, Berlin*, 1885, p. LXXXII; and also in *Report of Proceed. International Geological Congress*, by P. Frazer, p. 24, Philadelphia, 1885, where we read: "Dr. A. Geikie proposed that the congress postpone the subject of sub-dividing the Cambrian and Silurian until the meeting in England; on the ground that the Silurian question was mainly an English question. (Loud murmurs)."

Let us say at first that the whole region of the island of Newfoundland is the most important for the Taconic system, all the world over. The very name of *Terra nova* seems to be ironical, for on the whole earth there is not so large an area as old and entirely formed of the most antiquated strata which were ever deposited on our globe.

The southeastern part, from Bonavista bay to St. John's and Fortune bay, with its many profound bays or fjords, its numerous settlements, its railroad cuttings, offers the most splendid field for researches. There are the best and most complete series of strata containing the Infra-Primordial, the Primordial and the Supra-Primordial faunas.

As far back as 1839-40, when the Palæozoic rocks were almost unknown, so far as classifications and palæontology are concerned, my lamented friend, the late J. Beete Jukes, made a first reconnoissance of Newfoundland, and classified all that we know now as Lower, Middle and Upper Taconic, into two great slate formations, called Lower and Upper Slate formations. ("General Report of the Geological Survey of Newfoundland," London, 1843). No fossil was found by Jukes; and his classification—only very general, without any details—is entirely based on stratigraphical principles.

In 1859, the first fossil found in the whole island was sent to professor Salter, in London, who described it under the name of *Paradoxides bennettii*, showing the existence at Branch on the western side of St. Mary's bay, of the Primordial fauna of Barrande. In the year 1864, a new geological survey was begun by Alexander Murray, who soon took for his assistant Mr. James P. Howley, an excellent practical observer, who has done all the difficult work of stratigraphy and classification of the rocks in Newfoundland. Mr. Howley has not only surveyed and published the geological maps of Conception bay and Brigus bay, where are all the super-positions and corrugations of the Taconic system of southeastern Newfoundland ("Section Map near Brigus," 1881, and "Peninsula of Avalon," 1881); but to him is due the detailed geological section of Conception bay, p. 27 of the Annual Report for 1868; and what is more important the "Column of Primordial strata," published in the Annual Report for the year 1870, pp. 36, 37, 38 and 39, with a diagram.

In that column, which Mr. Howley had the great kindness to send me lately, with many manuscript notes to make it more clear, the division *n* contains all the *Paradoxides* beds; and below that great formation, Mr. Howley has found in his division *m*, which he calls Top-Sail Head, a special fauna, composed according to Billings and Mr. Matthew of the following species: *Paradoxides? Solenopleura bombifrons, Ptychoparia, Agraulos strenuus, Stenotheca paupera, Iphidea, Straparollina?* and *Hyolites micmac*. All those fossils belong to old forms, which can be easily compared with the fauna of the Scandinavian formation of Norway, Sweden and Britain.

Both Billings and Matthew, with their great knowledge of primordial trilobites, and Howley with his long practical experience in the field—three excellent judges—have referred the most important trilobite found in the "Top Sail Head division," or "horizon of *Agraulos strenuus*" as it is called by Mr. Matthew, to a primitive form of the *Paradoxides* family, and even Mr. Matthew goes so far as to point out its resemblance to *Paradoxides* (*Holmia*) *kjerulfi* ("On the Cambrian fauna of Cape Breton and Newfoundland, May, 1886, in *Trans. Roy. Soc. Canada*, p. 148). Billings in 1870 called it a "supposed *Paradoxides*." As all three know perfectly well the typical *Olenellus* (*Elliptocephalus*) *thompsoni* of Georgia, Belle Isle strait and Canada, and that instead of referring the fragment of trilobite of Top Sail Head to *Olenellus*, they were lead to compare it with a *Paradoxides*, is a strong proof of their acumen and great knowledge of the Paradoxidean forms. And to them is due not only the exact stratigraphic position of the strata, which in Newfoundland correspond to and are the exact equivalent of the Scandinavian group, but also the comparison and synchronism of the principal and most characteristic trilobite found there, with the *Holmia kjerulfi* of Norway and Scania. So that, since 1868, 1870 and 1886, thanks to the researches and discoveries of Messrs. Howley, Billings and Matthew, we know that in Newfoundland exists a group with a special fauna below the great *Paradoxides* zone, which corresponds harmoniously with the *Holmia* (*Paradoxides*) *kjerulfi* beds of Scandinavia. In 1888 Mr. Walcott visited, in Conception bay, the localities so long described and well classified by Mr. Howley; and as he is a very remarkable fossil finder, he succeeded in collecting a certain number of specimens at the old well known localities of Top Sail Head, Brigus Head and Manuel's brook. Here is the list for the division *m*, or "Top Sail Head group, or horizon of *Agraulos strenuus:*" ***Obolella atlantica, Kutorgina labradorica***, *Scenella reticulata,Stenotheca rugosa* andseveral varieties, *Hyolitellus micans*, *Hyolites princeps*, ***Platyceras primævum***, a Gasteropod, ***Microdiscus speciosus*** and two other species, *Olenellus brœggeri* new species, ***Avalonia manuelensis*** n. gen., n. sp., *Ptychoparia*, *Solenopleura* ***Bombifrons*** and another species, ***Agraulos strenuus*** and varieties. All those fossils belong to forms related to the fauna of the Scandinavian group of Scania, Lapland, Norway and Britain. I shall call attention to two points only; the absence in Newfoundland as well as in Europe of the genus ***Agnostus***, and the presence of a Paradoxidean form called ***Paradoxides*** by Billings, Matthew and Howley, and *Olenellus* by Mr. Walcott. Until now Mr. Walcott has not published a description with figure of his *Olenellus brœggeri*, so it is impossible to control in any way his reference of that new trilobite to the genus *Olenellus* (*Elliptocephalus*). But after the thorough researches of Dr. Holm, on the *Olenellus kjerulfi*, it is presumable that the Conception bay trilobite, like the Scandinavian species is not a true *Olenellus* and belongs to *Holmia*.

If Mr. Walcott had contented himself with his collection of fossils, which is certainly important and valuable, he would have rendered a true service to our knowledge of the primordial fauna of Newfoundland; but unhappily he had gone into an attempt to synchronize the strata of Newfoundland with those of Vermont, eastern New York, Massachusetts, Canada and the Rocky mountains, which is most confusing and at variance with facts. The fauna of the Scandinavian groups of Conception bay, is entirely different from the fauna of the Georgia group of Vermont, Canada, Western Newfoundland and Belle Isle strait. At Conception bay, all the forms found in Division *m*, Top Sail Head, Brigus and No. 2 of Manuel's Brook section, belong to older forms than the fossils of Georgia, Bic Harbor, etc.; and without entering into details, I shall confine my remarks to the trilobites called *Olenellus brœggeri*, and *Olenellus thompsoni*. All the trilobites of Scandianavia and Esthonia referred to *Olenellus*, do not belong to that genus, and as Mr. Walcott regards the Esthonian

Schmidtia mickwitzi and the Scandinavian *Holmia kjerulfi* as true *Olenelli* of the original typical form of Georgia, it is to be supposed that his *Olenellus brœggeri* is no more an *Olenellus* than the trilobite of Mickwitz and the trilobite of Kjerulf.

The whole synchronism of the Esthonian and Scandinavian formations with the Georgia formation is based entirely, according to Mr. Walcott's views, on the genus *Olenellus*. But it is certain that trilobites have been placed in that genus, which truly belong to other genera, and we are lead to conclude that a too hasty generalization has been given by Messrs. Walcott and Lapworth in their three papers entitled: "Stratigraphical Succession of the Cambrian Faunas in North America" (*Nature*, Oct. 4, 1888); "On the Discovery of the Olenellus Fauna in the Lower Cambrian Rocks of Britain" (*Geol. Magaz.*, Nov., 1888 reprinted in *Nature*, Dec. 27, 1888); and "Stratigraphic Position of the Olenellus Fauna in North America and Europe" (*Amer. Jr. Sc.*, May and June, 1889); where we read the following paragraphs: 1. "The brief paper (of Mr. Walcott). . . puts an end to a controversy between European and American Geologists, and brings into harmony the sequence and palæontology of the Cambrian Faunas on both sides of the Atlantic." 2. "It affords me (Mr. Walcott) pleasure to recognize the work of the Swedish geologists, and to fully coincide with their results, and thus finally establish on the two continents the true order of succession of the oldest known Paleozoic fauna." 3. "The relative position of the Middle and Lower Cambrian faunas is now changed in the American scheme of classification, the *Paradoxides* zone being removed to the Middle, and the *Olenellus* zone to the Lower division." 4. In all my (Mr. Walcott) previous papers the term Middle Cambrian is to be changed to Lower Cambrian, and Lower Cambrian to Middle Cambrian." We have there a *chassé-croisé* of Mr. Walcott, and a too hasty generalization of Mr. Lapworth, based on erroneous interpretation of fossil genera, and not only a total want of stratigraphic proofs but against the stratigraphy of the typical localities of Georgia and Bald mountain.

The truth is, that Mr. Walcott made a first mistake, in rejecting Murray and Howley's observations on the stratigraphy of Newfoundland in his "Second contribution to the Cambrian faunas of North America," p. 49, Washington, 1886, saying that their placing the "Top Sail Head strata" beneath the ***Paradoxides*** beds, was "without paleontologic and stratigraphic evidence," and now he proposes to replace that exploded mistake, by a second and greater one if possible, in synchronizing the *Olenellus* fauna of Georgia and of the Rocky Mountain region with the ***Holmia*** (*Olenellus?*) ***brœggeri*** fauna of Top Sail Head, Brigus and Manuel's brook.

Mr. Walcott's proposition to place the uppermost part of the Middle Taconic, which is the position truly occupied by the Georgia formation, below the *Paradoxides* zone and regard it as the lowest part of the Middle Taconic, which he calls Lower Cambrian, is not acceptable, for it is incorrect. Besides Mr. Walcott totally ignores the true Lower Taconic with its two great formations, the Esthonian and the Newfoundlandian.

It is regrettable to see such an extraordinary change in American classification, made in such a summary way, from publications issued officially by the United States Geological Survey in its ***Bulletins***; and what is still more strange is that the pretended correction is an error, for the ***Paradoxides*** beds of Braintree, St. Mary's bay and St. John (New Brunswick) are older than the *Olenellus* (*Elliptocephalus*) beds of Bald mountain, Georgia, Bic Harbor, Eureka, etc. The most which can be said, is that the Georgia formation may be contemporaneous and homotaxial with the uppermost beds of the ***Paradoxides*** beds. Such a transfer of a great group of a 3rd order of the Primordial fauna, is not so bad and confusing as the transfer of the whole Primordial fauna above the second fauna, as was advocated and maintained so long and with such force by Messrs. Hall, Logan and Dana. But it is no less to be regretted, and the list published by Mr. Walcott, pp. 388-389 (*loc. cit.*) in which he puts together all the fossils of the Georgia formation with those of the Scandinavian formation is very confusing, for in this list there are forms of fossil animals which have never lived together, all mixed without regard to their stratigraphic record. That list presents a formidable front of 55 genera and 127 species for the American fauna of the Scandinavian formation, when in truth the number of species and varieties is about 25 or 30 at most. In due time the number of 50 species may be reached, but it will take many years for it. As a résumé of the inferior part of the true Primordial fauna or fauna of the Scandinavian formation, we have a total of 17 species for Europe and 25 or 30 for Newfoundland; in all 47 species.

IV. BOHEMIAN FORMATION OR PARADOXIDES ZONE.—The first fossils special to this zone were found by Dr. Emmons, and published by him as far back as 1844. They were two trilobites *Atops trilineatus* and *Elliptocephala asaphoides* found near Bald mountain in eastern New York. To the great credit of Dr. Emmons he saw that the few fossils which he was able to gather, were special and characteristic of the series of strata, which he called Taconic System, below the Lower Silurian of Murchison, or Cambrian of Sedgwick. Barrande, without knowing the discovery of Emmons, described in 1846, the primordial fauna of Bohemia, showing its complete independence and its absolute difference from the second fauna. (Notice préliminaire sur le systéme Silurien et les trilobites de Bohême", pp. 8-22, Leipzic).

As soon as Barrande was able to consult Emmons' publications, which did not reach him until 1860, he at once recogonized the priority of the discovery of Emmons, and established on the most solid basis, the just claim of America, to the honor of naming the great series of strata below the second fauna or Champlain system, called Lower Silurian system in England by Murchison and Cambrian system by Sedgwick. If justice and honesty are in favor of using in the general classification of the world, the name Taconic system, it is right also to recognize that Barrande is the first who gave their full value to the fossil remains existing in that great special system, calling them, primordial fauna, and that his studies in Bohemia, truly created the primordial fauna. Barrande also, first of all showed the great value of the genus *Paradoxides*, in recognizing the existence of his primordial fauna, and consequently we are justified in consecrating the name *Bohemian formation* or *Paradoxides zone*, to designate that great and principal division of the Middle Taconic, in honor of Barrande and his splendid discoveries and work on the fauna of Ginetz and Skrey.

Bohemia.—After many years of very careful researches, Barrande found only 10 species of Primordial fossils at Skrey and Ginetz, the only two fossiliferous localities of the Bohemian basin.

The majority and most conspicuous of those fossils are trilobites to the number of 27 species: 12 *Paradoxides*, 4 *Conocephalites*, 2 *Hydrocephalus*, 2 *Ellipsocephalus*, 1 *Arionellus*, 1 *Sao* and 5 *Agnostus*. Besides, Barrande quotes 5 *Hyolites*, a *Theca*, a *Discina*, one *Orthis*, 4 ***Trochocystites*** and three undetermined forms. The prevalence of *Paradoxides* led Barrande to give to that genus an importance of the first order in classifying the lower Paleozoic strata; and since his numerous publications on the primordial fauna and more especially his splendid and most valuable work "Le systême Silurien du basin de la Bohême" all the trilobites having Paradoxidean forms and consequently allied more or less closely to ***Paradoxides***, have justly been regarded as the guide; all the strata containing them, are referred to the Taconic system or great primordial zones.

Sweden.—In this paper, we have given already the classification of Linnarsson of 1876, for the ***Paradoxides*** beds of Sweden, divided into five groups, the upper one being characterized by *Agnostus lævigatus* and the four others being characterized by *Parad. forchammeri*, *Parad. ølandicus*, *Parad. davidis* and *Parad. tessini*. More recently, 1884, Messrs. Tullberg and Nathorst in "Annexe explicative á la carte géologique le la Suéde," p. 21, Stockholm, give more details, and they have classified for Scania the "Schistes á Paradoxides" or "H. Etage inferieur" of the primordial fauna system into:

a. Beds with Agnostus lævigatus.
b.——id——id——Paradoxides forchhammeri.
c.——id——id——Agnostus lundgreni.
d.——id——id——Paradoxides davidis.
e.——id——id——Conocoryphe æqualis.
f.——id——id——Agnostus rex.
g.——id——id————id——intermedius.
h.——id——id——Microdiscus scanicus.
i.——id——id——Conocoryphe exsulans.
k.——id——id——Agnostus atavus.
l. Breccia limestone.
m. Black aluniferous slates.

The last division *n* belongs to the *Holmia kjerulfi* zone or Scandinavian formation. According to Linnarsson, the Bohemian formation or *Paradoxides* zone of Sweden, contains six species of *Paradoxides*, *Ellipsocephalus muticus*, three *Arionellus*, three *Anomocare*, three *Liostracus*. *Delichometopus succicus* three *Conocoryphe*, four *Solenopleura* and twelve *Agnostus*; 3 *Hyolithus*, 3 *Orthis*, 2 *Lingulella*, *Obolus*, *Obolella*, *Acrotreta*, *Acrothele*, *Kutorgina*, *Iphidea* and *Protospongia*. The *Agnosti* are very common in the upper beds of the formation, and the *Orthis* characterizes also the upper beds.

[To be continued.]

CRYSTALLOGENESIS.

By Dr. H. Hensoldt.
School of Mines, Columbia College, New York.

II.

The crystals of the isometric system, which are equi-axed, equi-expansive and singly refractive, are doubtless composed of particles which have experienced the least amount of compression, compatible with their symmetrical arrangement. They are either spherical or very nearly so, and it is significant that of the twenty-two elementary bodies of which the crystalline forms have been hitherto ascertained, no less than fifteen are referable to the isometric system. In the crystals of the tetragonal and hexagonal system the molecules are so compressed that structural differences are developed in two directions, and in the forms of the remaining systems three directions of structural variation have been similarly originated.

That the double refraction of crystals is not inherent in the molecules, but is an acquired property, is obvious from the fact that in crystallized silica (Quartz, Amethyst, etc.,) we have double refraction, while amorphous Silica (Flint, Opal, Tabasheer, etc.,) is singly refractive. If the molecules of water were identical in form with those of ice, they should also be endowed with the same properties, yet in ice we have double refraction, while water is singly refractive.

If we dissolve fifteen grains of Chloride of Sodium in an ounce of distilled water and allow a drop of this solution to evaporate slowly on a glass slide[7] under the microscope, we may learn, if we watch the process in its final stages with a "$\frac{1}{10}$th" objective of good definition—many of the secrets of crystal life. The commencement of the operation of crystalline forces is always signalled by the sudden appearance, in the previously clear and colorless field, of innumerable dark points, which in an incredibly short time, augment in volume, till a diameter of perhaps $\frac{1}{500}$th of a millimeter is reached. It is then observed that the particles are spherical in outline and that their darkness is only an optical illusion, caused by a broad diffraction-ring, for in reality they are quite transparent. They are evenly distributed over the field, and their "growth"—a kind of spontaneous swelling, which can be plainly followed—is uniform and simultaneous.

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[7] The slide should be previously cleaned with alcohol, and it is not advisable to accelerate the evaporating process by artificial means, such as heating the slide over a spirit lamp. On the contrary, the slower the evaporation, the better the phenomena here referred to are observed. Weak solutions give the best results, especially if the experiments are made in a cold room.

Then a startling transformation-scene is witnessed; no kaleidoscope-effect could be more marvelous. The particles appear to become suddenly endowed with polarity, they change their positions, roll about like billiard-balls in every direction, yet always in straight lines. For a moment all seems confusion, but, behold! some invisible "floor-master" is asserting his authority, and in another instant we have the first manifestation of a symmetry, destined to culminate in that perfect crystalline regularity, which has excited the wonder of all ages. The globules, originally scattered all over the field, are now arranged in lines or rows, like so many strings of beads. Some of these rows consist of only three or four globules, in others we can count ten, fifteen, twenty or more, and it would seem as if each spherical body was surrounded by a delicate film or pellicle, which prevents the dissipation of the internal molecular forces.

A series of rapid changes is now inaugurated, which can be followed only with the greatest difficulty, and of which it is almost impossible to give an intelligible account within the space here at our disposal. The globules in each line, by a sudden and simultaneous movement, unite and form solid rods, and there are grounds for believing that this solidification is due to the rupturing of the mysterious pellicle referred to. That the globules are endowed with polarity cannot for a moment be questioned, and—reasoning from analogy—we are driven to the conclusion that the north pole of one is attracted by the south pole of the other. A very close proximity would therefore, terminate in a sudden rush and collision. Within a fraction of a second after the formation of the rods (which are of uniform thickness, however much they may vary in length) we observe a general commotion among them. Each now appears to act as a separate bar-magnet, and while some unite at right angles, others range themselves, in close contact side by side, and form a symmetrical wall. Layer is piled on layer, each little rod falls mechanically into its proper place—no regiment of soldiers could "form up" with greater precision, and before we have time to realize the strangeness of the spectacle, the field is studded with little cubes of exquisite beauty.

What we have seen here in an evaporating drop of chloride of sodium may be observed in any other saline substance which we allow to crystallize under the microscope, with the sole difference that the diameter of the globules and the form of the ultimate crystals vary according to the nature of the substances employed. That in the formation of minute spherical bodies we have the first visible manifestation of crystalline activity, was announced as early as 1839 by H. F. Link[8] a German microscopist, who detected the globule in evaporating liquids, which is surprising, considering the inferiority of objectives at that period. He expressed the opinion that they were hollow, but Vogelsang in his admirable work "Die Krystalliten," published in 1875, clearly demonstrated their massive character. This work—a masterpiece of careful observation and originality—should be read and re-read by every petrographer, mineralogist, chemist, physicist, in short by every student of natural science.

Vogelsang, in his experiments, employed a solution of sulphur in bisulphide of carbon, which he mixed with a certain quantity of Canada balsam, in order to retard the crystallizing process. The mechanical resistance, offered by the viscous balsam, prevented the globulites from moving about with their accustomed alacrity, their evolutions could be slackened, accelerated or arrested at pleasure, so that it now became possible to observe every phase in that wonderful series of changes which lead from apparent chaos to extreme crystalline symmetry.

We have abundant proof that the changes here described must occur in precisely the same order whenever a *molten* mineral substance slowly solidifies, and in sections prepared from many vitreous rocks, such as obsidians, pitchstones, perlites, tachylites, etc., we observe every species of molecular arrangement, from the primary globulite to the complete crystal.

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[8] "Ueber die erste Enstehung der Krystalle."

Obsidians, especially, furnish us with the most interesting objects for studying the economy of crystal life, as they reveal an almost endless variety of intermediary forms. Some are perfect natural glasses, free from every trace of devitrification: here the cooling was too rapid to permit even the formation of globulites. In others we have the field crowded with spherical bodies of uniform size, evidently globulites which were arrested in their further development by the solidification of the matrix. A third section shows the globulites arranged in lines, a fourth is characterized by the presence of an immense number of hair-like rods, in a fifth the rods were evidently on the point of uniting into planes of symmetry when the process was interrupted, and as we extend our inquiry to specimens which solidified more leisurely we find a complete "permament record" of every step of crystalline activity.

Globulites and their various combination-products may also be observed in comparatively coarse-grained Basalts, Dolerites, Porphyrites, etc. and their presence does not always indicate a vitreous condition of the matrix. It must be remembered that rocks are usually of very heterogeneous composition and that the fusion temperature of one mineral often differs considerably from that of another. While Augite, for instance, will easily melt before the blowpipe, Orthoclase required an enormous temperature, and some minerals are practically infusible. When an eruptive mass, a lava, composed of, say, six different molten minerals, begins to cool, that mineral which requires the highest temperature in order to melt, will be the first to solidify. While it already has developed into more or less regular crystals, the others are still compelled to remain in a liquid or viscous condition, until the temperature is sufficiently lowered to permit their consolidation in the succession determined by their physical properties.

Now it may happen that after the individualization of several of the constituents of a cooling mass, the temperature sinks so rapidly that the remaining ones have no time to crystallize, thus we find in thin sections prepared from such rocks, side by side with, or between perfectly developed crystals of Feldspar, Amphibole or other easily recognizable minerals, vitreous and semi-vitreous patches of interstitial matter, crowded with endomorphs. What minerals they represent or what forms they would ultimately have assumed, if allowed to develop is in most cases impossible to determine, and even observers like Rosenbusch and Zirkel have recognized the hopelessness of the attempt by applying to these vitreous components such vague names as "undeveloped ground-mass," "amorphous matrix," interstitial paste, etc.

We enter here upon a department of petrographical science which presents much that is strange and mysterious. These incipient forms have been carefully studied by a number of able observers, but though a great deal has been written about them—from the time of Vogelsang's splendid monograph to recent treatises and devitrification-processes—we are still very much in the dark as to their real character. The mode of their origination is part of the great secret of crystal life, and when once we thoroughly understand the laws which govern the formation of these remarkable bodies, one of the most important tasks of petrographical philosophy will be accomplished.

EDITORIAL COMMENT.

The Philadelphia Meeting of the International Congress of Geologists.

The following official record of the history of the choice of Philadelphia, by the International Geological Congress as the place for the next meeting, and the subsequent attempt to substitute Washington, is inserted in the view of an unfortunate misunderstanding which has recently developed. It is hoped that it will enable every reader to form an independent opinion as to the nature of the considerations and influences brought to bear by the representatives of the United States Geological Survey, as well as the actual facts regarding the willingness and ability of Philadelphia to properly entertain the congress.

C. L. Herrick.

Early in 1885 the year of the last session of the International Geological Congress a form of invitation was signed by the greater number of large American institutions of learning and original research, asking the International Congress of Geologists to fix the next after the London session in the United States.

Another form of invitation to hold its sessions in the city of Philadelphia was signed by mayor Fitler, the heads of all the scientific and educational institutions in the city and its neighborhood; the U. S. Govt. Officers stationed there, the principal judges, lawyers, bankers, merchants, prominent citizens to the number of several hundred, and placed in the hands of Dr. Persifor Frazer, secretary of the American Committee of Nomenclature, for presentation to the Congress. As in proper order was necessary, these invitations were presented to the Council of the Congress in the morning session, Wednesday, Sept. 19, 1888 together with an invitation to choose New York. which was signed by a single citizen of that city. The following is a translation of the official action on these invitations.

Prof. von. Zittel warmly seconds this invitation as does also Prof. Hauchecorne, Stur, Hunt, Capellini and Macfarlane.

Prof. Hauchecorne said that the great distance and the considerable expenses of the voyage which would be the consequence are of a nature to prevent many geologists from taking part in the session in the United States. He asks if it would be possible to procure reductions of the cost of transportation. He thought if it were possible to obtain facilities of this kind a great number of his countrymen would take part in the Congress at Philadelphia.

Prof. Frazer thought that the cost of the transit across the ocean would be reduced to about one-half, because a similar reduction was made for the members of the British Association at the time of their visit to America in 1884. As to the excursion to the Rocky mountains, to the mineral deposits of the south, and to the great lakes he hoped that tickets would be obtained from the railroads almost gratuitously.

Dr. Sterry Hunt in seconding the invitation of Dr. Frazer said that in his quality of president of the reception committee of the British Association in Montreal in 1884, he knew that the different steamship lines and railroads made very considerable reductions.

Prof. von. Zittel proposed the acceptance of the invitation of the Congress to the United States, adding that the well known generosity of the Americans would make the visit easy. He was sure that many geologists would make the journey and as all the phenomena of nature are on a grand scale in America, it is almost necessary for every geologist to go and complete his studies on that great continent.

Prof. Capellini having made a voyage to the United States and Canada in 1853 and having received so many marks of hospitality, warmly supported the proposition of Prof. von. Zittel to accept the invitation to the United States.

Prof. Hauchecorne also supported the motion and said that many mining engineers who ought to be good geologists will be happy to go to America to study the famous mineral deposits of that continent. He recalled the fact that the Germans were among the first to exploit the beds of anthracite in the United States.

Prof. de Lapparent supported the proposition. The immense scale of all the phenomena of Nature on the continent of America will have the effect of enlarging the views of scientific men.

Prof. Stur, (speaking in German) said that the geologists of Austro-Hungary desired very much that the Congress should hold its session in Vienna; but after having heard the invitation to meet in the United States in 1891, he supported the proposition to accept this invitation in the hope that three years later, or in 1894 the members of the Congress will come to Vienna where he promises them a hearty reception.

Prof. Neumayr supported the proposition made by the United States geologists and hoped that the session of 1894 would be reserved for the city of Vienna.

Prof. Capellini thought that after having submitted the invitation of the United States to the Congress at its last session, a cablegram ought to be sent to the city which was chosen.

At the meeting of the Council of the Congress held Thursday morning 9:30: Sept. 20, 1888,

Prof. Capellini said that everybody was in accord that the next session of the Congress should be held in America, but as to the choice of a city he was of the opinion that it would be better to entrust it to a committee of Americans.

Prof. Dewalque thought that it could be decided by the Council itself.

Prof. de Lapparent was of the opinion that the decision ought to be made by the Americans.

Dr. Sterry Hunt reminded the members of the Council that Philadelphia had given a warm invitation, while the invitation from New York was signed by but a single individual.

Prof. Capellini repeated that he preferred to leave the choice to an American Committee.

Prof. Frazer feared that there was a misapprehension on the subject of the city, and the only object to be considered is to choose the city which is most suitable in all respects to the meeting of the Congress.

Prof. Capellini read the names of the North Americans present at the Congress to which he wished to add the names of Messrs. Hall and Dana. He was of the opinion that the Congress should confide to them the task of choosing a city for the meeting of the Congress and also of choosing a committee of organization.

Prof. de Lapparent believes that it would be of advantage to proceed according to the method proposed by the president.

Mr. Blanford wished to wait till to-morrow in order to have the attendance of all the American members.

Mr. Macfarlane was of the opinion that the Council should decide the question of the city without waiting longer.

Prof. Newberry observed that before its last session the Congress might receive invitations from other American cities such as Washington or Cambridge and he endorsed the proposition of Prof. Capellini to confide the choice to a committee of Americans.

Prof. Capellini said that if it were possible the committee would make its choice before the close of the Congress, but if it were not possible the committee could hold a meeting in America and announce its choice later. He proposed formally the following names: Messrs. Hall, Dana, Newberry, Frazer, Sterry Hunt, Marsh, Walcott, and Gilbert. The motion was adopted by a large majority. One member voted in the negative and one did not vote.

(Official proceedings of the Council of the Congress, issued in sheets.)

First session of the Provisional Committee. All the members of the committee named by the Council except Hall and Dana, were present, to-wit: Dr. Newberry, Dr. T. Sterry Hunt, Prof. O. C. Marsh, Dr. G. K. Gilbert, Mr. C. D. Walcott and Dr. Frazer.

Dr. Frazer moved that Dr. Newberry take the chair. Carried. It was asked what was the object of the committee's appointment.

Dr. Frazer stated that he understood it to be for the purpose of securing unanimity among the representatives of the United States in regard to the selection of a place of meeting of the Congress in the United States in 1891, and to determine with respect to a committe of organization. In answer to a question as to the full intention of the Council on the latter subject he replied that he was not clear.

Prof. Marsh said that he had been very much surprised to hear of the invitation from Philadelphia. He had heard Washington and New York spoken of but not Philadelphia.

Mr. Gilbert hoped that Washington would be chosen.

Dr. Hunt's preference was for Philadelphia.

Dr. Newberry said that he ought to favor New York, but he thought that the attractions of Washington were much greater than those of any other place.

Prof. Marsh suggested that the question of place be first taken up, and in order to bring the subject before the meeting he moved that this committee recommend Washington.

Mr. Gilbert seconded this motion and in answer to a question remarked that Columbian University, Willard's Hall, and the National Museum would offer facilities for the meeting places.

The vote was demanded for Washington or Philadelphia. For Washington: Mr. Gilbert and Prof. Marsh. For Philadelphia: Dr. Hunt, Mr. Walcott and Dr. Frazer. Mr. Gilbert thereupon changed his vote to Philadelphia. Prof. Marsh also changed his vote to Philadelphia. Philadelphia was thereupon declared to be the unanimous choice of the committee.

Mr. Walcott said that Prof. Judd, Mr. Macfarlane and Dr. Geikie had informed him that they understood this committee named by the Council to be the committee of organization.

It was moved and seconded that this committee take a recess of not more than fifteen minutes while the chairman ascertain from the official Secretaries what the further duty committed to this body was. During the temporary absence of the Chairman one of the official Secretaries, Dr. C. Le Neve Foster, entered the room and at the request of Dr. Frazer read the minute of the Council meeting which he had made as follows: "M. Capellini lit les noms des américains du nord présents au Congrès, auxquels il veut ajouter les noms de M. James Hall et de M. J. D. Dana; et ilest d'avis que le congrès devrait leur confier la tâche de choisir la ville pour la réunion du congrès, et celle de choisir le comité d'organisation."

Dr. Newberry suggested another meeting of this committee.

It was moved and seconded that we meet at the same place to-morrow at 9 A. M. Carried.

The committee then adjourned to meet at 9 A. M., on Sept. 21st.

Second Session. Sept. 21, 9. A. M. Present Drs Newberry, Hunt and Frazer, Prof. Marsh, Messrs. Walcott and Gilbert.

Dr. Frazer was requested to be Secretary to the Committee and accepted the position. Dr. Frazer was requested to read the minutes of the last meeting which he had taken, and did so. By unanimous vote these minutes were then accepted and declared official.

Prof. Marsh said that he had consulted with Prof. Capellini who had told him that the committee could take as long a time as it chose before reporting. After some informal discussion,

Dr. T. Sterry Hunt moved that the Secretary of this committee announce to the Council the unanimous recommendation of this committee that Philadelphia be chosen as the place of meeting of the next Congress; and that we adjourn to meet in New Haven, November 15th next during the meeting of the National Academy. Carried.

Mr. Gilbert before the adjournment of the committee expressed the wish that the Secretary would settle all doubts as to the name and functions of this committee at the immediately following meeting of the Council. The committee then adjourned.[1]

Friday September 21, 1888. The Council of the Congress assembled at 9:30 A. M.

Dr. Frazer inquired whether a small error had not crept into the account of the proceedings of the last session. He believed that in speaking of the American committee Prof Capellini and the others had employed the expression "provisional" and that the committee was a "provisional committee."

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[1] *Note.* Pursuant to the informal request of Mr. Gilbert, the Secretary submitted the questions of the name and functions of the committee to the Council which decided that the committee was a "Provisional Committee" and that it was charged with "forming a committee of organization" in addition to the work it had already completed, of selecting a place of meeting for the fifth session of the Congress.

Prof. Capellini said that he had spoken of the committee in the sense that it was a provisional committee with full power.

Dr. Frazer thought that the word "provisional" should be added to. This correction having been made the proceedings were adopted.

Prof. Prestwich (President) read the following telegram which had just been received:

"*From Washington, to Prestwich, President of the Geological Congress, 28 Jermyn St., London, England.* Earnest invitation for next meeting of Congress in Washington. Halls and printing will be provided; hospitalities extended. Powell, Director Geological Survey."

Prof. Prestwich thought that the question ought now to be sent back to the American committee. Mr. Evans was of the same opinion.

Dr. Frazer (after consultation with Dr. Newberry, Chairman of the Committee of Americans) explained that the question of the choice of a city had been discussed as if the telegram had arrived, and presented the following report: "The Provisional American Committee appointed by the Council to ascertain the opinion of the members from the United States on the subject of the choice of a place of meeting of the Congress in America, in 1891, has the honor to report that the city of Philadelphia has been chosen unanimously as the place of meeting."

Dr. Newberry said that the committee had accomplished its duty and that he was glad to say that it is a unanimous report.

Prof. Stefanescu moved that the report of Dr. Frazer be adopted.

Dr. T. Sterry Hunt said that the question of Washington or Philadelphia had been discussed and that the vote had been unanimous for the latter city.

Prof. Capellini said that it was not necessary that the Council discuss the question of the choice of a city because the report was unanimous, but he desired to congratulate the Council and the committee of Americans on this happy result.

The President, Prof. Prestwich, supported the proposition of Mr. Stefanescu to adopt the report of the Committee of Americans and to decide definitely that the meeting of 1891 should be held in Philadelphia.

Prof. Capellini desired to offer the thanks of the Council to major Powell for his invitation to Washington and the following message was sent:

"*To Powell, Director Geological Survey, Washington.* Invitation re-"ceived. Council heartily thank you. Philadelphia chosen."
"Prestwich, President."

The President, Prof. Prestwich said that he would submit the question of a definitive choice to the Congress itself.

[*Official Proceedings of the Council.*]

Meeting of the International Congress, Saturday, Sept. 22, 1888, 11 A. M. After the adoption of the minutes of the preceding session as corrected,

Prof. von Zittel, to whom the President (Prof. Prestwich) had yielded the chair, explained the manner in which the invitation of the city of Philadelphia had been presented to the Congress, and said that the Council had confided the choice of a city to a committee of Americans, as follows: Dana, Hall, Marsh, Newberry, Sterry Hunt and Walcott.[2] The decision of the Council as announced was adopted by the Congress unanimously.

Dr. Frazer said that the Congress having accepted the invitation to Philadelphia in 1891, he had been asked to explain the nature of this invitation which had been presented by his fellow citizens. There were two reasons on account of which the Congress has done well in selecting Philadelphia as its host. The first is that in 1891 the University of Pennsylvania will celebrate its centennial anniversary, in which celebration savants from all parts of the world will take part. The University of Pennsylvania is one of the five oldest universities of the American continent, and although it is with one exception best provided with halls, laboratories, and various buildings, it is intended to expend $3,000,000 to increase and render it more useful. The Provost of the University had permitted him to say that the necessary halls shall be put at the disposition of the Congress, and that all possible facilities shall be given to its members. As the exercises of the centennial will not commence till after the 23d of September, the halls will be free before that date. In addition to this, there is to be a session of the International Medical Congress at Washington at about the same time. But the principal reason for the invitation of the International Geological Congress to Philadelphia was that the committee which inaugurated the Congress is called the "Comité fondateur de Philadelphie," because it was created in 1876 during the celebration of the centennial anniversary of the Independence of the United States. The mayor; the principal officers of the city government; and of select and common councils; the judges of the different courts; the United States officers stationed in Philadelphia; the presidents of banks, of the great railways, and of the great industrial enterprises; the lawyers, business men, and professors,—in short, all the citizens united in offering a warm reception to the Congress. He was not able to give the exact figures, but as the officers of three great transcontinental railways who are in relation with the steamship companies had joined in the invitation, he did not hesitate to say that excursions at reduced prices would be arranged to the Rocky mountains, the great lakes, to the southwest, and probably also to Canada. Besides, it is probable that the cost of the ocean transit will be reduced one-half.

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[2] These words are wanting in the official account of the proceedings, but are entered from a note made in the Congress. This being the last day, there was no opportunity to revise the minutes and have them entered in the official report. There is no difference of opinion, however, as to the action having been taken.

Prof. von Zittel (acting President) said that the members of the Congress were delighted to hear what Dr. Frazer had just told them, and that he was certain that the Congress of 1891 would succeed.

* * * * * *

At the end of the proceedings of the last session of the Congress, President Prestwich declared the session closed and adjourned to Philadelphia in 1891. (*Official Comptes Rendus, London Session*).

Third session of the Provisional Committee, Nov. 15th, 1888, North Sheffield Hall, New Haven. Present, Prof. J. D. Dana, James Hall, O. C. Marsh, Persifor Frazer, Mr. C. D. Walcott, and Mr. C. K. Gilbert, and Dr. J. S. Newberry, Chairman. The minutes of the two previous meetings were read and approved. The chairman declared that the meeting was open for business and asked if any propositions were ready.

Mr. Gilbert offered the following resolution: That the selection of the organizing committee be by ballot as follows: Each member of our committee shall write on a ballot not to exceed twenty-five names, and all persons whose names appear on a majority of the ballots cast shall be declared elected. If less than twenty are thus elected, one or more additional ballots shall be taken, the chairman indicating in each case the number of names to be written.

Dr. Newberry thought that it was the duty of this committee to name another committee, and that with that this committee's functions ceased.

Dr. Frazer sketched the action of previous organizing committees before the sessions of Paris, Bologna, Berlin, and London.

Mr. Gilbert stated that he had had prepared by his clerk a list of the fellows of the American Association for the Advancement of Science, and from this he had prepared a smaller list of about fifty, comprising all the names of the larger for whom it was likely anyone would vote. He had added several names to these lists which seemed desirable, and laid the two lists before the members of this committee simply as aids to the memory in making their selections. The resolution offered by Mr. Gilbert was seconded and carried.

Mr. Walcott offered the following resolution: That the permanent organizing committee be authorized to add to its number. Seconded and carried.

Mr. Walcott offered the following: Resolved, that a temporary chairman shall be appointed for the permanent organizing committee by the Provisional Committee immediately after the election of the permanent organizing committee. Seconded and carried.

The Chairman then ordered the ballot to be taken according to the resolution offered by Mr. Gilbert. Mr. Walcott and Dr. Frazer were then appointed tellers, and a recess was taken, during which the vote was counted. On the re-assembling of the committee the tellers reported that the following gentlemen having each received a majority of the votes cast were elected members of the permanent committee of organization: C. A. Ashburner, J. C. Branner, T. C. Chamberlin, G. H. Cook, J. D. Dana, C. E. Dutton, W. M. Davis, G. K. Gilbert, James Hall, Angelo Heilprin, C. H. Hitchcock, Joseph Leidy, J. P. Lesley, Joseph LeConte, O. C. Marsh, J. S. Newberry, J. W. Powell, J. R. Proctor, N. S. Shaler, J. J. Stevenson, Alexander Winchell, H. S. Williams, R. P. Whitfield, C. D. Walcott. Twenty-four in all. The Provisional Committee then proceeded to the election of a temporary chairman of the permanent committee of organization. Dr. J. S. Newberry was nominated as chairman. No other nominations being made, the vote was taken and Dr. Newberry was elected.

Mr. Gilbert moved: That the first meeting of the permanent organizing committee be held at Washington, D. C., during the meeting of the National Academy of Science, in April, 1889; the precise place and the day and hour being fixed by the temporary chairman, who shall give due notice to the members of the committee. Seconded and carried.

Mr. Walcott offered the following: That the Secretary of the Provisional Committee is requested to furnish a copy of all the minutes of the proceedings of the Provisional Committee to the temporary chairman of the permanent organizing committee. Seconded and carried. It was moved and seconded that this committee do now adjourn. Carried. *Sine die.* *Persifor Frazer, Secretary.*

At the first meeting of the Permanent Organizing Committee, held in Washington, April, 1889, Dr. T. Sterry Hunt, E. D. Cope, and Persifor Frazer were added to the committee.

At the second meeting of the Permanent Organizing Committee, held in Philadelphia, November, 1889, it was decided to appoint three subcommittees, as follows:

On long excursions—Chairman, J. W. Powell. On programme—Chairman, C. E. Dutton. Local committee, Chairman, Lesley, Leidy, Frazer.

The secretary was requested to correspond with the general secretaries of the London session and ascertain whether or not the Bureau desired a change in the date of the next meeting from 1891 to 1892, in order to coincide with the period of the proposed Columbian Quadricentennial.

Minutes of Third Meeting. At the call of the Chairman the American

Committee of organization of the International Congress of Geologists met in Washington at the National Museum, Friday, April [illegible], at 2 P. M. The following members were present: Messrs. Cope, [illegible], Frazer, Gilbert, Hague, Hall, Lesley, Marsh, Newberry, Powell, Stevenson, Walcott, Whitfield, Williams and Winchell. J. S. Newberry in the chair. The minutes of the last meeting were read by the secretary and approved.

The *Secretary* reported that in accordance with the direction of the Committee (see page 11) he wrote a letter on Nov. 18th, 1889 to the general secretaries of the London Congress, asking them if the Bureau desired the time of the Congress to be postponed to correspond with time of the expected World's Fair in 1892. This action was taken in conformity with the resolution adopted by the Congress at its Paris meeting in 1878, investing the "Bureau actuel" with powers during the interval up to the next Congress, and committing to the general secretary charge of the correspondence (see p. 199).

The letter from the general secretaries, J. W. Hulke and William Topley, dated Dec. [illegible]th, 1889, was then read (see letter on file). The Secretary further stated that the American committee of organization not having expressed any recommendation regarding postponement, [illegible]

[illegible]

[illegible]

[illegible]

Professor Lesley further stated that under such circumstances he believed it impossible for the present committee to perform satisfactorily the duties with which they were charged, and at the proper time he would offer the resolution that the Local Committee be discharged. Mr. Frazer seconded the resolution, and said that it was impossible for him to devote the time and work required unless he was chairman: he did not desire the chairmanship, but he would not do the work without holding the office: if the General Committee would appoint him chairman he would do the best he could. It will cost 12,000 dollars,if publications are included, to take care of Congress,$8,000 if publications are left out. He did not agree that it would be a failure in Philadelphia, and protested against any postponement or change of place.

After several tentative motions, the resolution, that we do not ask for any postponement of Congress was passed.

Mr. Frazer read extracts from a letter from Provost William Pepper of the University of Pennsylvania, stating that the Centennial of the University, the holding of which was expected to be in 1891, and which was one of the strong reasons for inviting the Congress to meet in Philadelphia, would not be held in 1891, but probably in 1892, and that he (the Provost) hoped the Congress would not be held in 1891.

The resolution proposed above by professor Lesley was formally made as follows: *Resolved that the Local Committee be discharged.*

This was seconded by Dr. Frazer, put to vote, and passed with one dissenting vote.

Mr. Cope moved that the Chairman appoint another Committee: Seconded by Captain Dutton.

Professor Lesley urged that we should determine first the place; Frazer, that the time would not permit of change, nor would it be courteous to Philadelphia. A resolution was made and passed to lay the motion on the table.

Upon motion of *major Powell*, to test the sentiment of the Committee, and seconded by professor Lesley: Resolved that it is the opinion of this Committee that the place should be changed. Passed by a vote of eight to two. Messrs. Hall and Frazer explained their votes.

Major Powell moved that it is the sense of this meeting that the next Congress should be held in New York;—not seconded, but opposed by professor Stevenson.

Professor Lesley moved the following: Resolved that it is the sense of this meeting that the next meeting of the Congress should be held in Washington. The motion was seconded by professor Marsh. Dr. Frazer wished to go on record as opposing the motion. After some discussion this resolution was passed by a vote of nine to three. (Messrs. Hall, Cope, and Frazer voting No.) A formal motion, offered by Mr. Gilbert and seconded by Mr. Lesley, was then put as follows:

RESOLVED, *that this Committee recommend and request the Bureau of the Congress to authorize the holding of the next Congress in the city of Washington.*

The question was considered of importance and the secretary was directed to obtain the vote of each member of the Committee, and in case the resolution received the majority of votes of the committee, to communicate the resolution to the Bureau for its authorization.

Upon motion of professor Winchell it was resolved that the chairman notify Provost Pepper of the action of the committee, explaining in all due courtesy the difficulties met with by the local committee, and the fact that it appeared eminently desirable that the place of holding the Congress be changed from Philadelphia to Washington, without any discourtesty or failure of appreciation of the kindly invitation of the people of Philadelphia.

The meeting was adjourned subject to the call of the Chairman.

As soon as the Washington meeting of the permanent organizing committee was over the following letter was addressed to every member of the Bureau:

April 24, 1890.

Sir and Colleague:—

At a session of the General Committee charged with the preparations for the coming meeting of the International Geological Congress, which session was held in Washington on April 18, 1890, it was decided to request the Bureau to change the place of meeting and to transfer it from Philadelphia to Washington, on the pretext that there was incompatibility in the views of the members of the local committee consisting of Messrs. Lesley, Leidy, and Frazer. It is the duty of the undersigned to inform you without delay that the explanation is not correct. The opinion of the three members above mentioned, expressed at the only meeting they have held, was as harmonious and accordant as possible on all points. The only difference was that Prof. Lesley desired to yield the chairmanship of the local committee to Prof. Frazer on the vote of two of its members, and that the latter did not believe himself to be justified in accepting this arrangement without the authorization of the General Committee; an opinion in which Prof. Leidy joined. But this point of pure detail had nothing to do with the place of the meeting.

The undersigned members of this Bureau and of the General Committee protest against what they believe to be on the part of the General Committee an abuse of power delegated to it by the Congress, and they declare that in their opinion, this committee in proposing to the Bureau a change of the place originally designated has actedwith out ostensible cause, contrary to the wish of the Congress expressed by an unanimous vote.

Signed,

T. Sterry Hunt,
Joseph Leidy,
E. D. Cope,
Persifor Frazer.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Trenton Limestone as a source of petroleum and inflammable gas in Ohio and Indiana. By Edward Orton. (Extract from the Eighth Annual report United States Geol. Survey).

In 1885 the Census Bureau issued a portly volume entitled "Report on the Production, Technology, and uses of Petroleum and its Products," by Prof. S. F. Peckham—a work which was a marvel of completeness and erudition and was then apparently exhaustive of all then known or likely to be known of the natural history of the native petroleum compounds. But now we are called upon to notice a successor in a monograph dealing with new data and results.

In this memoir of 190 pages the remarkable history of the new Ohio gas field is so admirably told by the veteran Ohio geologist that it must take a permanent place among the romances of science. It is not the least virtue of the book that it is decidedly readable as well as eminently painstaking and accurate, and though written in 1887 it has suffered little from subsequent discoveries.

The work opens with a review of current theories as to the origin of gas and oil which confessedly owes much to the older work of Peckham, but those familiar with Dr. Orton's other writings need not be reminded that he rejects the distillation hypothesis of Peckham for Dr. Hunt's theory, which, however, is considerably modified to adapt it to recent discoveries in Ohio. The following summary briefly indicates the conclusions reached.

(1) Petroleum is derived from organic matter.

(2) It is more largely derived from vegetable than animal substances.

(3) Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales and is of vegetable origin.

(4) Petroleum of the Canada and Lima type is derived from limestones and is of animal origin.

(5) Petroleum has been produced at normal rock temperatures (in Ohio fields) and is not a product of destructive distillation of bituminous shales.

(6) The stock of petroleum in the rocks is already practically complete.

The second chapter contains a lucid discussion of the modes of accumulation of oil and gas. It may well be a matter of surprise to many that the anticlinal theory of gas location—obvious induction that it is—should have been so long seeking recognition as the history proves. The following chapter, embracing the history of the exploiting and development of the Findlay field, reads like a romance.

The first discovery on record of inflammable gas in the Findlay field was made while digging a well, three and a half miles south of the court house, in October, 1836. On lowering a torch into the excavation after nightfall to ascertain its condition, the workmen were startled by an explosion, and a flame of considerable volume was afterward found burning on the surface of the water below. The difficulty in finding potable water was,indeed, one of the most constant indications of the presence of gas. "From statements now made, it is clear that the presence of inflammable gas has been known in Findlay and its vicinity since the country was first occupied. There have always been surface indications here of pronounced character, the most conspicuous of which are the sulphureted water of wells and springs, the escape of gas from springs and rock-crevices, and its presence in numerous excavations carried down to the limestone rock * * * * But it is also clear that it was likewise universally deplored as a nuisance that must be endured because it could not be abated." The gas was first utilized in 1838 by means of a primitive reservoir and burner composed of an inverted sugar kettle and a gun barrel. The fire thus lighted has continued practically ever since, but the first person who is known to have recognized the larger possibilities of the Findlay gas was Dr. Chas. Oesterlin who long vainly attempted to interest his neighbors and to lead them to join him in drilling for a larger supply. In March 1883 Dr. Oesterlin organized the Findlay Natural Gas Co. with a capital stock of $5,000. The drilling of the Pioneer well developed several minor gas horizons but at 1,092 feet a horizon of solid highly crystalline limestone was reached, which proved a reservoir of high-pressure gas. The gas was lighted, and its blaze at night illuminated a circle of country 20 miles in diameter. The Pioneer well was successful. A new horizon of gas and oil, not dreamed of before, was brought to light and Findlay became the centre of inspiration of development of fossil power scarcely, if at all, inferior in value to the great petroleum reservoirs of western Pennsylvania and New York. The flow from this first well is estimated at 300,000 cubic feet per day. This much we condense from the account of the development of the new field.

The fourth chapter embraces the discussion of the geological elements in the problem. Incidentally this chapter illustrates the short-sighted policy of legislative action in aiding only what is speciously termed practical geology and discriminating against paleontology. Even the most minute fossils may have an important practical bearing. Excellent specimens of the almost microscopic shell *Leptobolus insignis H.* were brought up in fragments of shale from a depth of 1,200 feet and positively locate the horizon of the Utica slate. The fact that fossils are the only indubitable indices of the age of a rock cannot be too often reiterated. Attention is called to the petroliferous character of the Clinton which may yet acquire as great importance in the North as an oil-bearer as in the South as a source of iron.

As open to criticism we note the use of the term "Devonian shale" to include the Cleveland, Erie, and Huron shales. Prof. Orton states that "the belief that the great shale system would everywhere admit of the convenient and easily-applied system of division above stated has not proved well-founded." On the other hand Dr. Newberry forcibly claims that these three shales have nothing in common and Prof. C. L. Herrick has sought to indicate the nature of the conditions which locally combined elements of them all and interblended them in places with horizons of Hamilton habitus.

A very interesting generalization is stated in the concluding chapter viz., that the porous character of the limestone in the petroliferous district is due to a process of dolomitization which resulted in complete crystallization leaving interstitial pores and spaces capable of carrying large quantities of oil, gas, or water. This dolomitization of the Trenton limestone seems to have been in the main regional and confined to the upper portions of the limestone. A warping of the formation has resulted in the differentiation of the contents of the porous portions, the gas and oils seeking the highest levels and the salt water remaining at a lower but definite elevation in every field. Prof. Orton concludes "it is unsafe to count the Trenton limestone an oil rock or a gas rock in any locality unless it can be shown to have undergone the *dolomitic replacement* by which its porosity is assured. Even in case it has undergone this transformation it will not be found a reservoir of oil or gas in an important sense unless, in the accidents of its history, some parts of its deeply-buried surface have acquired the *relief* that is essential to a due separation of its liquid and gaseous contents." The report in matter and manner is admirable.

RECENT PUBLICATIONS.

2. *Proceedings of scientific societies.*

Synopsis of the Cretaceous foraminifera of New Jersey, A. Woodward from the Journal of the New York Microscopical Society, Dec. 1889.

On the Cheyenne sandstone and the Neocomian shales of Kansas, F. W. Cragin, Bul. Wash. College Laboratory, vol. 2, No. 11, March 1890.

The Geological Society of America has issued several bulletins of volume 1, viz:

Organization of the Geological Society of America, with proceedings of the semi-annual meeting held at Toronto, August 28-29, 1889. This bulletin contains abstracts of the following papers: Revision of the genus Orthis, James Hall; New genera and species of Dictyospongidæ. James Hall; The strength of the earth's crust, G. K. Gilbert; Boulder beds and boulder trains, T. C. Chamberlin; Trap dikes near Kennebunkport, Maine, J. F. Kemp; The Sylvania sand in Cuyahoga county, Ohio, Peter Neff. The following are published in full: Areas of Continental progress in North America, James D. Dana; Study of a line of displacement in the Grand Canon, C. D. Walcott; High continental elevation preceding the Pleistocene, J. W. Spencer; Ancient shores, boulder pavements, and high-level gravels, J. W. Spencer, pp. 1-86.

Origin of the rock-pressure of natural gas in the Trenton Limestone in Ohio and Indiana, E. Orton, pp. 87-98.

Notes on the surface geology of Alaska, I. C. Russell, pp. 99-162.

Note on the pre-Paleozoic surface of the Archean terranes of Canada; The internal relations and taxonomy of the Archean of Central Canada, A. C. Lawson, pp. 163-194.

Structure and origin of glacial sand plains, W. M. Davis, pp. 195-202.

Orographic movements in the Rocky mountains S. F. Emmons, pp. 245-286.

On the glacial phenomena in Canada, Robert Bell, pp. 287-310.

On the Pleistocene flora of Canada, Sir William Dawson and Prof. D. P. Penhallow, pp. 311-334.

The Journal of the Cin. Soc. Nat. Hist. vol. xii, No. 4, January, 1890 contains, New Lower Silurian bryozoa, by E. O. Ulrich, pp. 173-198.

The Topography of Florida, N. S. Shaler, Bul. Mus. Comp. Zool., vol. xvi. No. 7.

The mineral composition and geological occurrence of certain igneous rocks in the Yellowstone National park, Jos. P. Iddings. Bul-Phil. Soc., Washington, vol. xi, pp. 192-220.

3. *Papers in Scientific Journals.*

Can. Record of Science. On new plants from the Erian and Carboniferous, and on the characters and affinities of paleozoic gymnosperms, Sir. J. W. Dawson.

Am. Nat. Sept. No. Origin of the Loess, Jno. T. Campbell.

Am. Naturalist, Oct. No. Synopsis of the families of vertebrata, E. D. Cope. *Feb. No.* Review of the progress of American invertebrate, paleontology for the year 1889, C. R. Keyes. *Mar. No.* The teeth as evidence of evolution, W. C. Cohall; Genesis of the Actinocrinidæ, Chas. R. Keyes.

Am. Jour. Sci. Feb. No. Cretaceous plants from Martha's Vineyard, D. White; Review of R. W. Ells' second report on the geology of a portion of the province of Quebec, C. D. Walcott; Tracks of organic origin in rocks of the Animikie group, A. R. C. Selwyn. *March No.* Sedgwick and Murchison: Cambrian and Silurian, James D. Dana; Cretaceous of the British Columbian region—The Nanaimo group, Geo. M. Dawson; Celestite from Mineral county, W. Va., Geo. H. Williams; Mineral locality at Branchville, Ct. Fifth paper, Brush and Dana; Recent rock-flexure, Frank Cramer; Origin of the rock-pressure of the natural gas of the Trenton limestone of Ohio and Indiana, E. Orton. *April No.* Æolian sandstones of Fernando de Noronha, J. C. Branner; Occurrence of basalt dykes in the upper paleozoic series in central Appalachian Virginia, N. H. Darton, with notes on the petrography by J. S. Diller; Origin of the Soda granite and quartz-keratophyre of Pigeon point, W. S. Bayley; Occurrence of polycrase or of an allied species in both North and South Carolina, Hidden and Macintosh; Origin of some topographic features of central Texas, R. S. Tarr; Formation of silver silicate, J. D. Hawkins.

Ottawa Naturalist, No. for Jan. to March. Geological progress in Canada, R. W. Ells. (President's inaugural address). *April No.* The Mistassini region, A. P. Low.

Am. Antiquarian, March No. The cliff-dwellers and their works, Stephen D. Peet.

4. *Excerpts and Individual Publications.*

Annual report of the curator of the Museum of Comparative Zoology at Harvard College, 1888-89. A. Agassiz.

The history of the Niagara river, G. K. Gilbert, Albany. From the sixth annual report of the Commissioners of the state reservations at Niagara, 1889.

The horned Dinosauria of the Laramie, E. D. Cope. From the American Naturalist, published Dec. 17, 1889.

On excavations made in rocks by sea-urchins, J. Walter Fewkes. Am. Naturalist, Jan. 1890.

Reply to the questions of Mr. Selwyn on "Canadian Geological Classification for Quebec." Jules Marcou. Proc. Bos. Soc. Nat. Hist., vol. xxiv, 1889.

The Laramie group: Its geological relations, its economic importance, its fauna and flora. The rock-salt deposits of the Salina group of western New York. (abstract) J. S. Newberry. From Trans. N. Y. Acad. of Sciences, vol. ix, Nos. 1 and 2.

Museum history and museums of History. G. Brown Goode, *Am. Hist. Asso.*

Remarks upon extinct mammals of the United States, W. R. Shufeldt. *Am. Field,* vol. xxxii.

Some new Kansas industries, Robert Hay. Proc. Kas. State Bd. of Agriculture.

Biographical notice of Chas. A. Ashburner. J. P. Lesley, Trans. Am. Inst. Min. Eng. Feb. 1890.

Relations of the pinite of the Boston basin to the felsite and conglomerate, W. O. Crosby. Tech. Quart. Feb. 1890.

5. *Foreign Publications.*

Untersuchungen ueber Gesteine und Mineralien aus West-Indien. von J. A. Kloos. (Sammlungen d. geol. Reichs Museums in Leiden, 1889, S. 169).

Second report on the geology of a portion of the province of Quebec. R. W. Ells. Part K. Rep. of the Can. Geol. and Nat. Hist. Sur. for 1887, contains an appendix, in tabulated form, showing the systematic distribution of the fossils, and their localities, referred to in the report exclusive of those species obtained in the limestone conglomerate bands, by Henry M. Ami.

Proceedings and transactions of the Nova Scotian Institute of Natural Science, vol. vii, Part iii, contains: A geological recreation in Massachusetts centre, D. Honeyman; Ice in the Carboniferous period, Henry S. Poole; Glacial boulders of our fisheries, and invertebrates attached and detached, D. Honeyman; The geology of Cape Breton, the minerals of the Carboniferous, E. Gilpin.

Schriften d. nat. Ver. f. Schleswig-Holstein, B. viii, Erstes Heft, Kiel, contains: Ueber eine lokale Anhäufung miocänen Gesteins bei Itzshoe. E. Stolley; Ueber einige seltene Fossilien aus dem Diluvium und der Kreide. Sch. Holsteins, H. J. Haas.

A manual of palæontology. By H. Alleyne Nicholson and Richard Lydekker. Two volumes, 8vo. 1624 pp. Third edition, rewritten and enlarged. Blackwood & Sons, Edinburgh, 1889.

The evolution of climate. James Geikie, Scottish geographical magzine, Feb. 1890.

Földtani Közlöny. Nov.-Dec. 1889, contains: Rhyolithspuren in Schweden. Dr. J. Szadeczky; Ueber einige seltenere Gesteinseinschlüsse in ungarischen Trachyten Franz Schafarzik; Der Stephansgang und seine Uebenklüfte, Paul Hegedüs; Kleinere phytopaläontologische Mittheilungen, Dr. M. Staub.

Ueber die rothen und bunten Mergelder oberen Dyas bei Manchester. H. B. Geinitz, Geo. Isis in Dresden, 1889, Abh. 3.

Summary Report of the operations of the Geological and Natural History survey, Ottawa. A. R. C. Selwyn.

CORRESPONDENCE.

POSTSCRIPT TO ARTICLE ON "THE MAQUOKETA SHALES."—Since the foregoing was put in type Mr. Leverett has kindly sent me some additional data of the Indiana gas borings. The following items are taken from his letter.

In a well at Terre Haute, the Trenton lime-stone was reached at a depth of 2,860 feet or 2,400 feet below sea level. In my discussion of the records given in table No. 1, it is stated that a well at Terre Haute was carried down 2,000 feet and stopped in the Corniferous lime-stone; and that if the rocks of the Cincinnati group continued to dip at the same rate as between Plainfield and Danville, the top of the group would be 1512 feet below sea level. From the later data the depth is even greater than this, probably 2,200 feet below sea level, if present at all.

At Rockville, which is about 40 miles west of Danville and close to the line of section west from Richmond, (No. 1) the Trenton was about 1,400 feet below sea level, as against 518 feet at Danville. The exact thickness of the Cincinnati group is not ascertained.

Rensselaer, again, is on the direct line of the second section, drawn north-west from Richmond. Mr. Leverett's data from a well there indicates an altitude of some 70 or 100 feet for the top of the Cincinnati rocks above tide, and a thickness for them of 300 feet. These figures correspond well with the others given in my second table.

Other well records are given by Mr. Leverett, but not being on the lines of section treated of, they are not mentioned here. It will be enough to say that the additional information confirms the deductions made in the body of the paper.

JOSEPH F. JAMES.

Washington, D. C. May 5, 1890.

PERSONAL AND SCIENTIFIC NEWS.

THE CHAIR OF GEOLOGY AND NATURAL HISTORY at Granville, O. left vacant by the call of Prof. Herrick to the corresponding chair in the University of Cincinnati, has been filled by Prof. W. G. Tight, under whose conduct the bulletin of the laboratories of Denison University will be continued. The fifth volume of this publication will contain, among other geological papers, stratigraphical notes on the Waverly in north-central Ohio by W. F. Cooper, who seeks to verify and extend the correlations suggested for the central and southern counties in previous numbers.

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ERRATA.

Vol. IV., p. 359, 18th line for "dividing," read *deciding*.
Idem., 13th line from bottom for "spine," read *spire*.
Vol. V., p. 62, last line for 5735 read 57350.
p. 168, four lines from bottom for "color and uppermost type," read *cover and uppermost top*.
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The Geological Survey of New Hampshire, Missouri, Michigan, [illegible]

The Atlases of the U. S. Geological Survey, to accompany [illegible] Emmons' Leadville, Becker's Comstock Lode, and Dutton's Tertiary History of the Grand Cañon District.

[illegible] Scientific and Geological works.

LITHOGRAPHIC WORK OF ALL KINDS EXECUTED IN THE BEST STYLE OF THE ART.

[illegible]

[illegible]